

***United States Court of Appeals
for the Second Circuit***



APPENDIX

77-4157

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No. 77-4157

United States Court of Appeals
For the Second Circuit

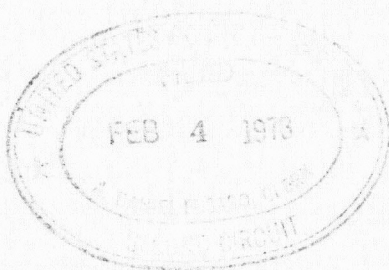
NATURAL RESOURCES DEFENSE COUNCIL, INC.,
Petitioner,

vs.

UNITED STATES NUCLEAR REGULATORY COM-
MISSION and UNITED STATES OF AMERICA,
Respondents.

Petition for Review of an
Order of the Nuclear Regulatory Commission

JOINT APPENDIX



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UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

NATURAL RESOURCES DEFENSE COUNCIL
PETITION FOR RULEMAKING

Docket No. FRM-50-18

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BEFORE THE UNITED STATES NUCLEAR REGULATORY COMMISSION

In the matter of

Required Atomic Energy Act)
 Safety Determination Regarding)
 Disposal of High-Level Radio-)
 active Wastes)

NRC Docket No. _____

PETITION OF THE
 NATURAL RESOURCES DEFENSE COUNCIL
 FOR A DETERMINATION, PRIOR TO
 ISSUANCE OF REACTOR OPERATING
 LICENSES, WHETHER RADIOACTIVE
 WASTES CAN BE DISPOSED OF SAFELY

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Attorney for Petitioner

BEFORE THE UNITED STATES NUCLEAR REGULATORY COMMISSION

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PETITION OF THE
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WASTES CAN BE DISPOSED OF SAFELY

The provisions of the Atomic Energy Act of 1954, 42 U.S.C. §§ 2011 et seq., and the Nuclear Regulatory Commission's regulations require that the Commission determine, before issuing a reactor license, that there is "reasonable assurance that the activities authorized by the operating license can be conducted without endangering the health and safety of the public" and that "the issuance of the license will not be inimical . . . to the health and safety of the public." 10 C.F.R. § 50.57(a)(3), (a)(6). Based on this obligation, the Natural Resources Defense Council, Inc. ("NRDC"), on its own behalf and on behalf of its members, hereby petitions the Nuclear Regulatory Commission ("NRC") to make a definitive finding whether high-level

radioactive wastes^{1/} can be safely disposed of without undue risk to the public health and safety. This petition seeks to have the Commission apply the relevant safety standards of the Atomic Energy Act of 1954 to determine whether or not high-level radioactive wastes that will be generated in reactors can be safely disposed of before the Commission acts to grant operating licenses to power reactors. Petitioners contend that the provisions of the Atomic Energy Act of 1954, the Energy Reorganization Act of 1974, and the Commission's regulations require the Commission to follow this procedure.

THE PETITIONER

Petitioner Natural Resources Defense Council, Inc., is a non-profit, membership corporation organized under the laws of the State of New York. NRDC is a charitable organization exempt from taxation under Section 501(c)(3) of the Internal Revenue Code. NRDC's principal office and place of business is located at 15 West 44th Street, New York, New York. It maintains other offices at 917 15th Street, N.W., Washington, D.C. and at 2345 Yale Street, Palo Alto, California. NRDC has a nationwide membership of persons dedi-

^{1/} As used in this Petition, "high-level radioactive wastes" means (1) high-level wastes as defined in 10 C.F.R. Part 50 Appendix F, (2) spent fuel rods, and (3) transuranic-contaminated wastes.

cated to the defense and preservation of the human environment and the natural resources of the United States. Other persons support NRDC's objectives by financial contributions and personal efforts.

The objectives of NRDC include:

- (a) to maintain and enhance the quality of the human environment;
- (b) to monitor federal departments and regulatory agencies to ensure that environmental values are fully considered in decisionmaking, and, in particular, to ensure that federal statutes designed to protect and enhance the environment are fully and properly implemented;
- (c) to improve federal agency decision-making which affects the environment by commenting, furnishing information, and initiating and participating in administrative proceedings;
- (d) to select and undertake environmental lawsuits which have a potential for establishing widely applicable precedents for saving, reclaiming, or protecting some important aspect of our national endowment, including the health and safety of the public; and
- (e) to provide a central, national focus for scientists, lawyers, educators, and concerned citizens in an effort to make our courts and administrative agencies effective instruments of environmental protection.

In pursuit of its objectives, NRDC has been involved in many proceedings involving the Atomic Energy Commission and now the Nuclear Regulatory Commission.

PETITIONER'S INTEREST IN
THE PROCEEDING

NRDC's basic interest in the captioned proceeding is twofold: (1) to protect present and future NRDC members, their progeny, and the public by ensuring the public is adequately protected from increased risks of cancer and genetic mutations that might be produced by the creation of further amounts of radioactive wastes in the absence of a determination that they can be safely disposed of, and (2) to protect present and future NRDC members, their progeny, and the public who live or travel near to disposal sites for radioactive wastes by ensuring further wastes are not produced unless disposal practices exist or will exist that provide adequate protection against off-site migration of radioactivity.

BASIS FOR REQUEST

A. NRC's Legal Obligations

Pursuant to § 201(f) of the Energy Reorganization Act of 1974, 42 U.S.C. § 5481(f), the Nuclear Regulatory Commission carries out its licensing and related regulatory functions under the provisions of the Atomic Energy Act, 42 U.S.C. §§ 2011 et seq. ("AEA"). The provisions of the AEA direct NRC to protect the health and safety of the public through its licensing authority. Congress specifically found that

the "processing and utilization" of nuclear materials "must be regulated . . . to protect the health and safety of the public." 42 U.S.C. 2012(d) (1972).

The AEA contains the further finding of Congress that "regulation by the United States of the production and utilization of atomic energy and of the facilities used in connection therewith is necessary . . . to protect the health and safety of the public." 42 U.S.C. § 2012(e) (1972). And in articulating the purposes of the AEA, Congress declared its intention to provide for a "program to encourage widespread participation in the development and utilization of atomic energy for peaceful purposes to the maximum extent consistent with . . . the health and safety of the public." 42 U.S.C. § 2013(d) (1972).

Furthermore, in creating the Nuclear Regulatory Commission, Congress specifically declared its intention in the Energy Reorganization Act ("ERA") "to advance the goals of restoring, protecting, and enhancing environmental quality, and to assure public health and safety." 42 U.S.C. § 5801(a). The Senate committee that was primarily responsible for drafting the ERA emphasized that the NRC was to "upgrade the regulation of nuclear power" and stated that the provisions of the ERA were "to guarantee that the new Commission will have the strength and autonomy to carry out its awesome safety, health and environmental responsibilities." Sen. Report No. 93-980, 93rd Cong., 2d Sess., at 3, 21 (1974).

The Supreme Court has recognized the safety requirements of these provisions of the Atomic Energy Act. The Court has noted that the Act "clearly contemplates that the Commission shall by regulations, set forth what the public safety requires as a prerequisite to any license or permit under the Act." Power Reactor Development Company v. International Union, 367 U.S. 396, 404 (1961). Accord, Citizens for Safe Power v. NRC, 524 F.2d 1291, 8 ERC 1598, 1604 (D.C. Cir. 1975). See also New Hampshire v. Atomic Energy Commission, 406 F.2d 170 (1st Cir. 1969), cert. denied, 395 U.S. 962 (1970).

In issuing a license for a nuclear power reactor, the Commission's obligation to protect public health and safety applies at two stages: the construction permit stage and the operating license stage. At the construction permit stage, the Commission's regulations, 10 C.F.R. § 50.35(a), make clear that the Commission may issue a construction permit even if further research and development is required for needed safety features or components. The construction permit may be issued if the applicant "has identified, and there will be conducted, a research and development program reasonably designed to resolve any safety questions," and the Commission determines that, on the basis of the identified R&D program, reasonable assurance exists that safety questions will be satisfactorily resolved before construction is completed. 10 C.F.R. § 50.35(a)(3)-(4).

By contrast, however, when an operating license is sought, the Commission must make a much fuller determination. Specifically, the Atomic Energy Act requires the Commission to determine that there will be "adequate protection to the health and safety of the public." 42 U.S.C. § 3332(a). See Citizens for Safe Power v. NRC, 524 F.2d 1291, 8 ERC 1598, 1602 n. 12 (D.C. Cir. 1976). In applying this provision, the Commission's regulations require that the Commission must find reasonable assurance that "the activities authorized by the operating license can be conducted without endangering the health and safety of the public" and "the issuance of the license will not be inimical . . . to the health and safety of the public." 10 C.F.R. § 50.57(a)(3) and (a)(6) (emphasis added).

The Supreme Court itself has emphasized the distinction between the two stages of the licensing process. In Power Reactor, supra, the Court approved the Commission's formulation that it could approve a construction permit based on reasonable assurance that a research and development program would resolve any unanswered safety questions. The Court pointed out that the Commission had explicitly stated in its Power Reactor proceedings that "a construction permit is provisional upon further demonstration of many technological and financial facts, including the complete safety of the reactor." 367 U.S., at 402. Thus, the Court held that the Commission could defer a "definitive safety finding" until the operating

license was actually issued. Id., at 407. Even more precisely, the Court emphasized the following acknowledgment by the Commission:

"The degree of 'reasonable assurance' ...that satisfies us...for purposes of the provisional construction permit would not be the same as we would require in considering the issuance of the operating license." Id., at 403.

The Court made clear that a definitive safety finding would have to be made before operation was actually permitted.

Similarly, the decisions of the Courts of Appeals since the Power Reactor case have recognized the need for a full safety finding by the Commission prior to the issuance of an operating license. For example, in Nader v. NRC, 513 F.2d 1069, 7 ERC 2059 (D.C. Cir. 1975), the Court emphasized the obligation of the Commission under 42 U.S.C. § 2232(a) (1970) to determine that a facility will afford "adequate protection to the health and safety of the public" before issuing an operating license. 7 ERC, at 2063. The Court there noted the Commission's interpretation that this statutory obligation represented a demand for "reasonable assurance" of that protection. Id.

In the Nader case, the D.C. Circuit emphasized that the Commission had satisfied its statutory obligation, in large part, by conducting a rulemaking to set forth design criteria for the emergency core cooling system that assured that those systems and components of a nuclear power reactor would "provide reasonable assurance that the facility can be operated without undue risk to the health and safety

of the public." 7 ERC, at 2063 (quoting Commission language). Similarly, Citizens for Safe Power v. NRC, 524 F.2d 1291 (D.C. Cir. 1975), and North Ana Environmental Coalition v. NRC, 533 F.2d 655, 8 ERC 1770 (D.C. Cir. 1976), recognized the statutory requirement that an operating license must provide "adequate protection to the health and safety of the public, which the Commission has chosen to implement through regulations requiring its 'reasonable assurance' and not 'inimical' findings."

And while these subsequent Courts of Appeals decisions recognize that the Commission need not guarantee that reactor operation will be "risk-free," they make clear there can be no blinking the need to make a full safety determination as required by the Atomic Energy Act and the Commission's regulations.

B. The Commission's Safety Determination Must Include A Finding Relative To Waste Disposal As Well As To Reactor Operation.

One of the inevitable by-products of operating a nuclear power reactor is the creation of massive amounts of plutonium and other highly radioactive materials. During its projected 40-year life span, a one-thousand megawatt nuclear power plant can be expected to generate eight metric tons of plutonium^{2/}, as well as millions of curies of other

^{2/} See U.S. Nuclear Regulatory Commission, Final Generic Environmental Impact Statement on the Use of Recycle Plutonium in Mixed Oxide Fuel in Light Water Cooled Reactors, Vol. 2, at II-3 (NUREG-0002) (August 1976).

highly toxic radioactive elements. Plainly, a determination that operation of such a reactor will not create undue risk to public health and safety requires a determination that these highly hazardous and long-lived radioactive materials can be disposed of safely.

The United States Court of Appeals for the District of Columbia Circuit has recently spelled out the hazardous nature of the wastes produced:

"Nor are the wastes generated by the subject reactor de minimis. We were informed at argument that the Vermont Yankee plant will produce approximately 160 pounds of plutonium wastes annually during its 40-year life span. Plutonium is generally accepted as among the most toxic substances known; inhalation of a single microscopic particle is thought to be sufficient to cause cancer. Moreover, with a half-life of 25,000 years, plutonium must be isolated from the environment for 250,000 years before it becomes harmless. Operation of the facility in question will also produce substantial quantities of other 'high-level' radioactive wastes in the form of strontium-90 and cesium-137 which, with their shorter 30-year half-lives, must be isolated from the environment for 'only' 600 to 1000 years."

* * *

"Once a series of reactors is operating, it is too late to consider whether the wastes they generate should have been produced, no matter how costly and impractical reprocessing and waste disposal turn out to be; all that remain are engineering details to make the best of the situation which has been created." Natural Resources Defense Council v. NRC, Nos. 74-1385, 74-1586, F.2d, Slip Opinion, at 6-7, 11 (D.C. Cir. July 21, 1976).

The Court had earlier taken note that the production of radioactive wastes in itself represented a health hazard. In Scientists' Institute for Public Information, Inc. v. AEC, ("SIPI"), 481 F.2d 1079, 1098 (1973), the Court observed

"These wastes will pose an admitted hazard to human health for hundreds of years, and will have to be maintained in special repositories."

To license a reactor as safe plainly requires the Commission also to determine that the highly hazardous wastes it creates can be handled and permanently disposed of safely.

C. Substantial Doubt Exists Whether Reactor Wastes Can Be Disposed Of Without Creating Undue Risk To The Public Health and Safety

Petitioner alleges that the hazards posed by the radioactive wastes created during the operation of nuclear power reactors -- when evaluated in the current absence of an acceptably safe plan and means for disposal -- constitute an extremely significant and undue risk to the public health and safety. Specifically, petitioners allege that no adequately safe disposal plan has been approved and that creation of additional radioactive wastes in new reactors at the present time in the absence of an accepted plan for disposing of these wastes does not provide for adequate protection to the health and safety of the public, in violation of the Atomic Energy Act of 1954.

Petitioner specifically alleges:

(1) No accepted and approved plan exists for permanent disposal of high-level radioactive wastes. Edward A. Mason, a member of this Commission, has written,

"Simply stated, although several available technologies have been researched, demonstration-scale information is lacking and no agreed-upon plan for long-term, high-level waste management exists."3/

Major and significant uncertainties exist in present plans for disposing of spent fuel rods, high-level radioactive wastes, and transuranic wastes. NRDC has set out some of the uncertainties in these areas in other documents, which are submitted herewith as Exhibit A.

(2) A recent government-sponsored report, prepared at the MIT Energy Laboratory and endorsed by respected and knowledgeable nuclear engineers including Dr. Norman Rasmussen, has thrown doubt on the ability of the government to devise an acceptably safe disposal plan and carry it out effectively. The Report concluded:

"The existing organization for radioactive waste management will be unworkable if left unchanged."

"The existing framework for radioactive waste regulation will be ineffective if left unchanged."4/

3/ NRC News Releases Vol. 1, No. 34, p. 8 (Week ending September 30, 1976).

4/ Willrich, M., Radioactive Waste Management and Regulation, A Report to the U.S. Energy Research and Development Administration from the MIT Energy Laboratory, at 1-5, 1-7 (August 27, 1976 Draft).

A copy of this Report is submitted herewith as Exhibit B.

(3) As carried out at the government's two major production sites and at the one reprocessing plant to operate, radioactive waste management has not been handled in a manner acceptably safe for the long-term.^{5/} NRDC has set out the extent of the problems confronted by the government's plants in a memorandum to ERDA and to the Commission which is submitted herewith as Exhibit C.

Not only do these facts raise grave questions concerning the ability of the government to protect adequately the public's health and safety once hazardous radioactive wastes are created, they also challenge the Commission's ability to make the findings required by the Atomic Energy Act. This precise question has been addressed by Dr. M. J. Steindler of the Argonne National Laboratory. In a paper prepared for a Commission Workshop,^{6/} which is set out in full in Exhibit D herewith, Dr. Steindler pointed out the extremely incomplete state of knowledge concerning the long-term safety of geologic disposal. In his judgment, the

^{5/} See, e.g., Willrich, M., supra note 4, at 3-28 to 3-35; Battelle Pacific Northwest Laboratory, Alternative Processes for Managing Commercial High-Level Radioactive Wastes, at 51-52, passim (NUREG-0043) (April 1976).

^{6/} Steindler, M.J., "Partitioning of Nuclear Wastes; How, Why, and When," in Proceedings of Nuclear Regulatory Commission Workshop on The Management of Radioactive Waste: Waste Partitioning as an Alternative, at 380 (NR-CONF-001, June 8-10, 1976).

inadequacy of the data precludes licensing determinations under the Atomic Energy Act that proposed waste disposal methods in fact protect the public health and safety:

"This generally inadequate state of scientific information about the environment of the waste in the depositories is perhaps the major factor contributing to our inability to provide licensing reviews that will assure that the safety of the public will be protected." Proceedings, supra note 6, at 383 (emphasis added).

Dr. Steindler goes on to assert in fact that licensing determinations concerning the safety of waste disposal will have to adopt different standards, if licensing approvals are to be issued:

"Because of these difficulties, licensing actions on waste disposal are likely to take on a radically different tone. When required to provide expert opinions on geologic phenomena in the long time frame required, few if any reputable geologists are likely to insist that a particular depository selected by ERDA or industry will remain stable. Further, materials scientists may encounter the same difficulties when discussing very long-term leach rates, transport properties, or other phenomena important to safety issues. Finally, the experimental bases for conclusions drawn about the interaction of waste and environment will be essentially absent. Under these conditions, the licensing agencies will have to proceed on bases with which neither the public nor the agencies are particularly satisfied or familiar. Specifically, most evidence used to evaluate the safety issues will be based on extreme extrapolations of uncertain information, little of which will be subject to test. The normal, strongly redundant approaches which the public has come to expect from the nuclear industry will be absent." Proceedings, supra note 6, at 384 (emphasis added)

Petitioner believes that the Commission is authorized by the Atomic Energy Act to apply only one standard. If the present uncertainty concerning the safety of proposed methods of waste disposal means that the needed determinations cannot be made except under a weaker standards, the Commission is not free to dilute the safety requirements of the Atomic Energy Act. Whether weaker safety standards should be applied to waste disposal is for the Congress, not the Commission, to decide.

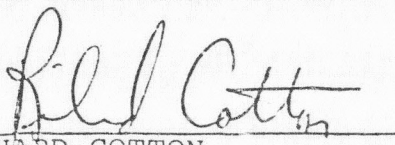
CONCLUSION

Based on the reasons set out above, petitioner requests the Commission (1) to conduct a rulemaking for the explicit purpose of determining whether radioactive wastes can be generated in nuclear power reactors and subsequently disposed of without undue risk to the public health and safety, and (2) to refrain from acting finally to grant pending or future requests for reactor operating licenses until such time as this definitive finding of safety can be and is made.

Respectfully submitted,

NATURAL RESOURCES DEFENSE COUNCIL

BY


RICHARD COTTON

(Natural Resources Defense Council)
2345 Yale Street
Palo Alto, California 94306

Attorney for Petitioner

Dated: November 8, 1976

BEFORE THE UNITED STATES NUCLEAR REGULATORY COMMISSION

In the matter of	)	
	)	
Required Atomic Energy Act	)	
Safety Determination Regarding	)	NRC Docket No. _____
Disposal of High-Level Radio-	)	
active Wastes	)	
_____	)	

PETITION OF THE
 NATURAL RESOURCES DEFENSE COUNCIL
 FOR A DETERMINATION, PRIOR TO
 ISSUANCE OF REACTOR OPERATING
 LICENSES, WHETHER RADIOACTIVE
 WASTES CAN BE DISPOSED OF SAFELY

EXHIBIT B

RICHARD COTTON, ESQ.
 (Natural Resources
 Defense Council, Inc.)
 2345 Yale Street
 Palo Alto, California 94306

Attorney for Petitioner

EXHIBIT B

Radioactive Waste Management and Regulation

A Report to the U.S. Energy Research and
Development Administration from the
M.I.T. Energy Laboratory

by

Mason Willrich

(August 27, 1976)



Energy Laboratory
Massachusetts Institute of Technology
Cambridge, Massachusetts 02139
(617) 253-3400

August 27, 1976

Dr. Robert C. Seamans, Jr.
Administrator
U.S. Energy Research and
Development Administration
Washington, D.C. 20545

Dear Dr. Seamans:

It is a pleasure to forward herewith for your review and comment our draft report on Radioactive Waste Management and Regulation. This report is submitted in accordance with ERDA Institutional Agreement No. E(49-18)-2295, Task Order No. 14. Comments are due on September 30, and our final report is due on October 15.

The report deals primarily with institutional arrangements necessary for the safe management of post-fission radioactive waste which results from the U.S. commercial nuclear power industry and the U.S. nuclear weapon production program. Based on our analysis of the existing situation and alternatives available, the principal conclusions of the report are:

-- The existing organization for radioactive waste management will be unworkable if left unchanged.

-- The existing framework for radioactive waste regulation will be ineffective if left unchanged.

The principal recommendations are:

-- A national Radioactive Waste Authority should be established, separate from ERDA, as a federally chartered public corporation to manage all high-level and transuranic contaminated wastes under U.S. Jurisdiction or control.

-- With NRC as the primary agency, a comprehensive regulatory framework should be established to assure the safety of all radioactive waste management operations under U.S. jurisdiction or control.

Dr. Robert C. Seamans, Jr.

August 27, 1976

-- ERDA should continue to have primary government responsibility for research and development of radioactive waste technology for purposes of both management and regulation.

-- The U.S. government should propose that an international Radioactive Waste Commission be established under the International Atomic Energy Agency (IAEA).

-- The pending NRC decisional process concerning commercial reprocessing and widescale use of mixed oxide fuel should be expanded to include full analysis of radioactive waste implications along with economic, health and safety and safeguards issues.

I hope you find the draft report and its conclusions and recommendations to be helpful in your consideration of ways to deal with an important issue in the future development of nuclear power.

I look forward to receiving comments from ERDA and other interested government agencies and would be pleased to meet with you and your staff for discussions.

After September 1, please use the following address:

Mason Willrich
Director, International Relations Division
The Rockefeller Foundation
1133 Avenue of the Americas
New York, New York 10036
(212) 869-8500

Sincerely,

Mason Willrich
Visiting Professor of Nuclear
Engineering

MW:ajs
Enc.

September 1 Draft: not to be reproduced or distributed without
author's consent; comments due on or before September 30.

RADIOACTIVE WASTE MANAGEMENT AND REGULATION

by: Mason Willrich

with: Stephen C. Greenberg
Richard K. Lester
H. Clyde Mitchell
Daniel A. Walker

Report to the U.S. Energy Research and
Development Administration from the
M.I.T. Energy Laboratory

Foreword

This report on Radioactive Waste Management and Regulation by Mason Willrich contains the results of a research project conducted under the auspices of the Energy Laboratory at the Massachusetts Institute of Technology (MIT Energy Lab) for the U.S. Energy Research and Development Administration (ERDA).

The project began June 1 and ended September 1, 1976. Mason Willrich, currently Director for International Relations of The Rockefeller Foundation, served as principal investigator during this period when he was also Visiting Professor of Nuclear Engineering at MIT. Professor Willrich was assisted by an interdisciplinary group drawn from MIT and the University of Virginia, where he is Professor of Law (on leave). The research group included Stephen C. Greenberg, Virginia law student, Richard K. Lester, MIT nuclear engineering graduate student, H. Clyde Mitchell, MIT undergraduate (now a Virginia law student), and Daniel A. Walker, Virginia law student.

The views expressed in the report are Professor Willrich's and do not necessarily represent the views of any other person or any public or private institution. However, the report has been reviewed by Norman C. Rasmussen, Chairman of MIT Nuclear Engineering Department and by David J. Rose, Professor of Nuclear Engineering at MIT, both of whom support its conclusions and recommendations.

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Chapter 1

INTRODUCTION AND SUMMARY

The vast bulk of radioactive waste in the U.S. has been and will continue to be generated by two programs: the commercial use of nuclear materials to generate electricity; and the military use of similar materials for nuclear weapons and naval propulsion. Until now, most of the radioactive waste has resulted from military activities. However, the commercial nuclear power industry has now become the major source of additional waste. Radioactive waste is thus an unavoidable consequence of our nuclear age.

Due to their intense and persistent toxicity, some types of waste must be effectively isolated from the biosphere for hundreds of thousands of years. Safe management of this waste surely requires technological excellence, but the social and political issues are at least as demanding. Radioactive waste poses an existing and permanent challenge to government.

Purpose

The purpose of this report is to assist in developing public policy and institutions which are necessary for the safe management of radioactive waste, currently and in the long term. Indeed, an underlying hope is that the report will accelerate such development by the U.S. government.

Scope

The report focuses on the management and regulation of post-fission radioactive waste generated in the U.S. This includes

so-called high-level (HL) and transuranic contaminated low-level (TRU) wastes.

In the commercial nuclear power industry, the source of post-fission radioactive waste is the spent fuel discharged from reactors used to generate electricity. HL waste is generated during the reprocessing of spent fuel--a chemical operation in which depleted uranium and by-product plutonium are recovered. TRU waste results primarily from reprocessing and from the fabrication of fresh fuel containing recovered plutonium.

Similarly, with regard to military uses of nuclear energy, post-fission radioactive waste originates in fuel removed from stationary reactors which produce plutonium for nuclear weapons or mobile reactors which provide propulsion for naval ships. Military HL waste emerges at a reprocessing plant, while military TRU waste is generated during reprocessing, and also in the manufacture of nuclear weapons.

Management of post-fission radioactive waste embraces a series of discrete but deeply interdependent operations. These operations include collection, temporary storage, treatment, packaging, transport, and permanent disposition. Regulation of waste management operations to assure safety is also composed of a number of discrete, interrelated, activities. Regulatory activities include development of general criteria and specific standards, and application of established standards and criteria in licensing waste management operations. The licensing process itself includes review and approval: of sites, of the design and construction of facilities, and of the conduct of operations. Regulation also encompasses the

monitoring of previously licensed operations, prescription of emergency actions, and enforcement of obligations in the event of violations of legal requirements.

Post-fission HL and TRU wastes are not the only radioactive wastes which require safe management and regulation. Every step in the nuclear fuel cycle--mining and milling, enrichment, fuel fabrication, reactor operation, reprocessing, and plutonium and uranium recycling--creates radioactive discharges in various forms. Depending on its toxicity, a waste stream is either actively managed or else released to the environment. Moreover, various parts of nuclear fuel cycle facilities will continue to be dangerously radioactive long after the facilities themselves are shut down, and these parts will require safe handling. This report focuses on HL and TRU waste streams because they raise the most pressing and difficult management and regulatory issues.

Finally, although the report focuses on the U.S., important international dimensions are taken into account. Ineffective management of radioactive waste in one country may cause harmful effects in another. Moreover, low-level radioactive waste is being dumped in the ocean, and geologic disposal of HL waste beneath the ocean floor is being considered. Most of the oceans and the deep seabed are beyond the limits of national jurisdiction.

Conclusions Summarized

1. Safe management of post-fission radioactive waste is a present necessity and an irreversible long-term commitment.

A rapidly growing number of spent fuel assemblies are accumulating in temporary storage pools at commercial nuclear power .

plants, pending a government decision on whether to authorize reprocessing. If commercial reprocessing is not authorized, the spent fuel must be safely managed indefinitely. A small volume of commercial HL waste is being stored temporarily in tanks adjacent to a reprocessing plant that is now shut down for modification and expansion. Commercial TRU waste has been disposed of previously in relatively small amounts at various shallow land burial and ocean dump sites.

However, existing military wastes will constitute a much larger and more difficult management problem in the near future than the wastes being generated by the commercial nuclear power industry. A large and still growing amount of military HL waste is being temporarily stored in tanks. No specific plans or schedule has been made public for treatment and permanent disposition of this waste. Rough estimates of the cost of preparing the existing inventory of military HL waste for safe permanent disposition run up to \$20 billion. Very little is publicly known about management of military TRU waste, although a large amount is involved.

2. The basic goals of U.S. radioactive waste policy are unclear.

The basic technological criteria for permanent disposition of commercial HL waste are containment and isolation from the biosphere for as long as necessary to prevent it from being or becoming a harmful source of radiation. There is quite widespread agreement on this goal, but controversy surrounds the question of how it will be achieved.

The basic technological goal regarding TRU waste is unclear and undecided, although the quantities of plutonium contained in this

category of commercial waste will be comparable to the plutonium quantities in HL waste if commercial reprocessing is authorized and partitioning of long-lived actinides is not required. Some dilution and dispersal of TRU waste is presently permissible, although the trend is toward requiring permanent methods of disposition for such wastes that are more or less equivalent to methods suitable for HL waste.

The technological criteria for military HL and TRU waste management are unclear. Some critics fear that temporary tank storage of solidified HL waste will become a permanent disposition of existing volumes.

In general, radioactive waste policy contains no criteria to apply in developing institutional arrangements for waste management and regulation. Yet institutional effectiveness is an essential ingredient of safe management.

3. The existing organization for radioactive waste management will be unworkable if left unchanged.

Management of commercial HL waste is divided between private industry and the federal government. The private sector is responsible for temporary storage, treatment, packaging, and transport, while the federal government (presumably the Energy Research and Development Administration (ERDA)) is responsible for permanent disposition. Bifurcated responsibility for an essentially integrated series of waste management operations creates incentives for each sector to pass through to the other as much as possible of the risks and costs. Moreover, in such a framework, underlying trade-offs between short- and long-term considerations are difficult to make.

Thus, the existing structure tends to prevent, rather than to facilitate, the efficient management of commercial HL waste.

All management functions for commercial TRU waste have rested with the private sector until now. Proposed Nuclear Regulatory Commission (NRC) regulations, however, would shift the task of permanent disposition to ERDA. Collection, temporary storage, treatment, packaging, and transportation will continue to be managed by the private sector.

ERDA is responsible for all stages in the management of most military HL and TRU wastes, but some military waste is apparently managed in the short-term by the Department of Defense (DOD). Most operations are conducted for ERDA by private contractors. The federal government (presumably ERDA) is responsible for permanent disposition of military HL waste.

In the case of both commercial and military HL waste, permanent disposition is authorized only at a federal repository on federal land. State land use regulation of the location of permanent repositories for HL waste is thus ultimately preempted by federal law. Nevertheless, a state government may effectively oppose, through political means and legal procedural delays, attempts by the federal government to establish a federal repository within its borders without its consent.

One pervasive deficiency in the existing waste management structure is that it does not tend to generate strong internal incentives for efficient management. Management incentives, to the extent that they exist, are supplied mainly by external forces such as government regulation and public criticism. Since existing military wastes are self-regulated by ERDA, as discussed below,

incentives for safe and efficient management of these wastes may be especially low.

Another fundamental deficiency is the inadequacy of the structure for developing and implementing comprehensive and integrated waste management strategies, from temporary storage to permanent disposition, for all categories of post-fission radioactive waste.

4. The existing framework for radioactive waste regulation will be ineffective if left unchanged.

NRC has primary, comprehensive authority to license commercial HL and TRU waste operations from temporary storage through permanent disposition. However, NRC has delegated regulatory authority over TRU waste to certain states. State regulation has been ineffective in some instances. The Department of Transportation (DOT) has concurrent regulatory authority with NRC over the transport of radioactive waste.

NRC has authority to license the permanent disposition of military HL waste, but lacks authority to license the temporary storage and treatment of such waste. NRC has no licensing authority over military TRU waste. Therefore, no independent regulatory agency licenses existing military post-fission radioactive waste to assure the public health and safety. Nevertheless, military HL and TRU wastes constitute the vast bulk of those in existence, and incidents have occurred which raise doubts about the safety of ERDA's military waste management operations.

Ocean disposal of HL waste is currently prohibited by U.S. legislation and international law, and ice sheet disposal in

the Antarctic is prohibited by the Antarctic Treaty. The Environmental Protection Agency (EPA) has concurrent jurisdiction with NRC over ocean dumping of TRU waste, although all such U.S. activity has been suspended.

The federal scheme of regulation basically preempts state safety regulation. State land use regulation may, however, operate to affect the location of all radioactive waste operations, except permanent disposition of HL waste at a federal repository. The location of such a repository is a federal matter which ultimately preempts state law. However, as noted above, political and procedural means are available for state opposition.

Pervading the entire framework for radioactive waste regulation are two further features: (1) EPA is responsible for developing generally applicable environmental standards for radiation protection; and (2) the National Environmental Policy Act (NEPA) requires a particular procedure, including preparation of an environmental impact statement, for major federal actions regarding radioactive waste management and regulation.

A major area of regulatory uncertainty concerns whether NRC has authority to license ERDA demonstrations of methods for permanent disposition of HL waste. Such demonstrations, though on a small scale, may be potentially hazardous in themselves. They may also create momentum for rapid expansion into a full scale operation, thereby tending to bias a later safety review.

Recommendations Summarized

1. U.S. radioactive waste policy goals should be clarified.

The technical concepts of containment and isolation should be developed more specifically and applied to TRU waste as well

as HL waste. These concepts should also be applied to every phase of post-fission radioactive waste management from temporary storage through permanent disposition.

In addition, institutional criteria should be incorporated into radioactive waste policy. Important criteria would be:

- strong incentives;
- clear differentiation of management, regulation, and research and development functions;
- ample jurisdiction for each functional component to perform all interdependent operations within an area of responsibility; and
- adaptability to a changing social environment.

2. A national Radioactive Waste Authority should be established as a federally chartered public corporation. The Authority would manage all HL and TRU wastes under U.S. jurisdiction or control.

The Authority would be independent of ERDA. It would be governed by a board of directors composed of members drawn from government, nuclear industry, the academic research community, and the general public.

The Authority would own all HL and TRU waste facilities, including facilities for temporary storage, treatment and permanent disposition of waste, and any specially constructed waste transport containers. It would take over existing commercial and military waste facilities.

The Authority would be self-financing. It would issue bonds and recover the full costs of providing waste management services from its customers. It would be authorized to conduct

waste management operations itself or to contract with private industry for the conduct of such operations.

The Radioactive Waste Authority would thus be intended to provide comprehensive, integrated, efficient management of both commercial and military HL and TRU wastes.

3. With NRC as the primary agency, a comprehensive regulatory framework should be established to assure the safety of all radioactive waste management operations under U.S. jurisdiction or control.

All HL and TRU waste operations, whether involving commercial or military waste would be subject to NRC licensing. Licensing would be required of existing (unlicensed) military wastes, as well as future commercial and military wastes. Various categories of waste from diverse sources may be regulated differently in appropriate circumstances, but all regulation would occur within a unified framework, headed by NRC. Other interested federal and state agencies would play advisory roles.

4. ERDA should continue to have primary government responsibility for research and development of radioactive waste technology.

That responsibility would, however, be separated from management, on the one hand, and regulation, on the other. ERDA-supported radioactive waste research and development would be planned to be responsive to the needs of both the NRC and the proposed national Radioactive Waste Authority.

5. The U.S. government should propose that an international Radioactive Waste Commission be established under the International Atomic Energy Agency (IAEA).

The IAEA Commission would license any disposition of HL or TRU waste which would result in dispersal or emplacement beyond the limits of national jurisdiction. The Commission would review and comment on proposals for permanent geologic disposition of HL or TRU waste within national jurisdiction.

6. The pending NRC decisional process concerning commercial reprocessing and widescale use of mixed oxide fuel should be expanded to include the issues of radioactive waste partitioning, HL and TRU waste management, and spent fuel management in the event of no reprocessing.

In the NRC's regulatory decision concerning commercial reprocessing, analysis of the radioactive waste management implications should receive in-depth analysis, along with economic, environmental, and safeguards issues. NEPA appears to require such an expansion of the issues to be fully considered. It should be possible to include full consideration of waste management implications of commercial reprocessing and recycling without additional delay in the NRC decision in view of ERDA's forthcoming environmental impact statement on the subject.

Chapter 2

RADIOACTIVE WASTE

This chapter is intended to provide readers who have not previously considered the radioactive waste problem with the information they will need to understand the analysis of waste management and regulation that follows. The discussion is written with the non-technical reader in mind.

Radioactivity

Radiation is the emission and propagation of energy through matter or space. Radioactive materials emit energy in the form of electromagnetic radiation, such as gamma or X-rays, or in the form of fast moving sub-atomic particles such as alpha-particles (the nuclei of helium atoms) and beta particles (electrons), both of which carry an electric charge, and neutrons, which carry no electric charge. As radiation penetrates matter, it interacts with its environment, and energy is transferred to the surrounding atoms resulting in their ionization. If the radiation is interacting with organic tissue, the ionized atoms acquire new and different properties and may break down or enter into abnormal chemical combinations which may cause the decomposition or synthesis of complex molecules. The net effect is to destroy living cells and to damage the exposed tissue.

The energies of the different emissions listed previously vary widely and so do their penetrating powers. For example, alpha radiation is not very penetrating compared with gamma, and, to a lesser extent, beta. Unlike these two, therefore, it does not constitute a major hazard to man if the radiation source is external. If the

source of radioactivity is inhaled or ingested, however, then all three types of radiation are important, because of the close proximity of living tissue.

We are concerned about radioactive waste because it is a potential radiological hazard to man and other forms of life. A scale against which our concern can be measured is the fact that we all live in a radioactive environment. The biosphere--that thin envelope of soil, water and air which contains and sustains all life on Earth--receives radiation from outer space and from many areas in the Earth's crust. Since the beginning of this century, man has begun to add to this naturally occurring "background" radioactivity. Medical x-rays, normal nuclear power plant operations, and nuclear weapons tests are all sources of ionizing radiation. Depending on where a person lives and what he does, he is exposed to more or less radiation. A person living in Denver, Colorado which is located near uranium ore deposits at an elevation of about 1 mile above sea level, receives more radiation than a person working in a normally functioning nuclear power plant on the James River in Virginia and living nearby.

When a radioactive nucleus* emits radiation--usually an alpha or beta particle or a gamma ray--it "decays" to another nucleus which itself may or may not be radioactive. A sequence of decays involving two or more radioactive nuclei is called a "decay chain". Clearly, every decay chain terminates with a stable, non-radioactive nucleus.

Each type of radioactive nucleus, or radioisotope, has a

*The nucleus is the positively-charged core of an atom, composed of protons and neutrons.

characteristic fractional decay rate. Of course, it does not make sense to talk about the "fractional decay rate" of an individual nucleus, since at any instant the nucleus in question either will or will not have decayed. But the concept becomes meaningful if, as is invariably the case, we are dealing with a large number of nuclei of the same type. In this situation we can legitimately speak of a collective fractional decay rate. A commonly used measure of decay rate is the radioactive half-life. This may be defined as the length of time required for half of the nuclei in a sample of a radioisotope to decay to another nuclear form.

The half-lives of different radioisotopes span an enormous range from millionths of a second to billions of years. After a period of time equal to 10 half-lives, the radioactivity of a radioisotope has decreased to 0.1 percent of its original level. Table 2.1 indicates the half-lives of some of the major constituents of radioactive waste. In order to calculate the amount of radioactivity from a particular source, it is not sufficient to know only the half-life of the radioisotope involved. It is also necessary to know the quantity present. The level of radioactivity, which is the product of the quantity of a particular radioisotope and the fractional decay rate, is measured in curies.*

We need to know more than the number of curies, however, in order to estimate the biological significance of a volume of material

*A Curie is a unit which measures the rate of nuclear decay. One curie is defined as being equal to 3.7×10^{10} nuclear decays (or disintegrations) per second. It should be noted that this unit does not distinguish either the energy or type of radiation that is emitted during a decay.

TABLE 2.1 - Half-Lives of Some of the
Major Constituents of Radioactive Waste

<u>Radionuclide</u>	<u>Half-life (Years)</u>
Americium - 241	460
Americium - 242	150
Cesium - 135	2,000,000
Cesium - 137	30
Curium - 242	.45
Curium - 243	12
Curium - 244	18
Iodine - 129	16,000,000
Krypton - 85	10.8
Neptunium - 237	2,100,000
Plutonium - 239	24,000
Plutonium - 241	13
Radium - 226	1,600
Strontium - 90	29
Technicium- 99	200,000
Thorium - 230	76,000
Tritium	13

that contains one or more radioisotopes, perhaps mixed with non-radioactive materials. All radioactivity is not the same. As we have seen, different radioisotopes emit different forms of radiation at different energies as they decay.

Furthermore, different living organisms and different organs within the same organism all have varying degrees of sensitivity to radiation. Since many effects of ionizing radiation are cumulative, individual exposure histories are important, and these, together with individual radiation tolerance levels, can vary significantly. For internal sources of radiation, the physical and chemical form of the radioisotope and its route of intake are also important.

If a human being is exposed to excessive amounts of radiation, depending on the circumstances, the harmful effects may be immediate death, life shortened by radiation-induced cancer, radiation-induced genetic change which may affect subsequent generations, or temporary ill-health followed by complete recovery. It is important to note that excessive exposure to harmful levels of ionizing radiation may be caused by contact with a particular radiation source or multiple contacts with many sources. The rate of absorption of radiation is also important, since damaged tissue has more chance to recover from radiation effects if the exposure takes place over an extended period rather than during a sudden burst.

How then do we protect ourselves from the potentially harmful effects of excessive radiation? Although the relation between the magnitude of radiation dose* and the resulting effect on human

*Dose may be defined as the quantity of energy imparted to a mass of material exposed to radiation. A dose unit is the rad, which is equal to one hundred ergs of absorbed energy per gram of absorbing material. Another dose unit is the rem (roentgen equivalent man) which is the dose of any ionizing radiation that will produce the same biological effect as that produced by 1 roentgen of high voltage X-radiation. It is related to the rad by a quality factor, the relative biological equivalent (RBE).

health is difficult to determine, the government nevertheless establishes dose limits, or Maximum Permissible Doses, which are standards for radioactive emissions from routine activities. On the basis of aggregate values for the breathing rate and the daily consumption of drinking water for an average person, it is possible to calculate the dose to each body organ that would be likely to result from a given, continuous concentration of a particular radionuclide in air or water. These calculations, together with the Maximum Permissible Doses, allow the critical or most sensitive organ to be identified for each radionuclide and method of intake. It is also possible to calculate, for each radionuclide, the concentration in air and water that, if continuously maintained, would result in the Maximum Permissible Dose to the critical organ. This is called the Maximum Permissible Concentration (MPC).

The calculated MPC values are, therefore, a measure of the radiotoxicity of a nuclide and are frequently used in calculations of radiological hazard. The MPC measure is imperfect, however. It accounts only for radiation exposure resulting from breathing contaminated air and drinking contaminated water. In particular, it does not take into account the effects of biological reconcentration of a radionuclide that has been previously released to the environment. Therefore, a reliable estimate of the radiation dose to the population resulting from the presence of a particular radioactive source requires a detailed study of the particular environment and its demographic characteristics in order to identify the critical pathways to population exposure.

Post-Fission Radioactive Waste

"Radioactive waste" may be defined broadly as being waste material that is contaminated or possibly contaminated by radioactive isotopes. More precisely, radioactive waste is residual material that is removed from the nuclear fuel cycle and held because its release would constitute a hazard to man or the environment. Such waste does not include radioactive emissions, within prescribed limits, which occur during the normal operations of various nuclear facilities. As we use the term, "waste" includes residual material from which certain materials may be sooner or later recovered and recycled.

Post-fission radioactive waste is generated by nuclear fission in power reactors which produce electricity for commercial use, and also in reactors which produce plutonium for nuclear weapons and in propulsion reactors for submarines, missile cruisers, and aircraft carriers. This is the commercial and military post-fission waste that is the subject of the study.

Post-fission radioactive waste may be differentiated into various categories such as high-level (HL), transuranic* contaminated low-level (TRU), and non-TRU waste. Such a categorization does not necessarily provide a key to potential hazards, however, since these also depend on external factors.

HL waste is composed of hundreds of radioisotopes, some in trace amounts and some in very high concentrations, some with short and some with extremely long half-lives. Various isotopes are typi-

*Transuranic means having an atomic number greater than uranium, that is, greater than 92 (e.g., neptunium, plutonium, americium, curium, etc.).

cally gamma or beta or alpha emitters. HL waste is thus a veritable witches' brew, seething with radioactivity. Because of the long half-lives of some of the radioisotopes it contains, HL waste would, if it escaped into the biosphere, constitute a radiological hazard for hundreds of thousands, perhaps a million years. (See Figure 2.1 showing HL waste radioactivity over time.)

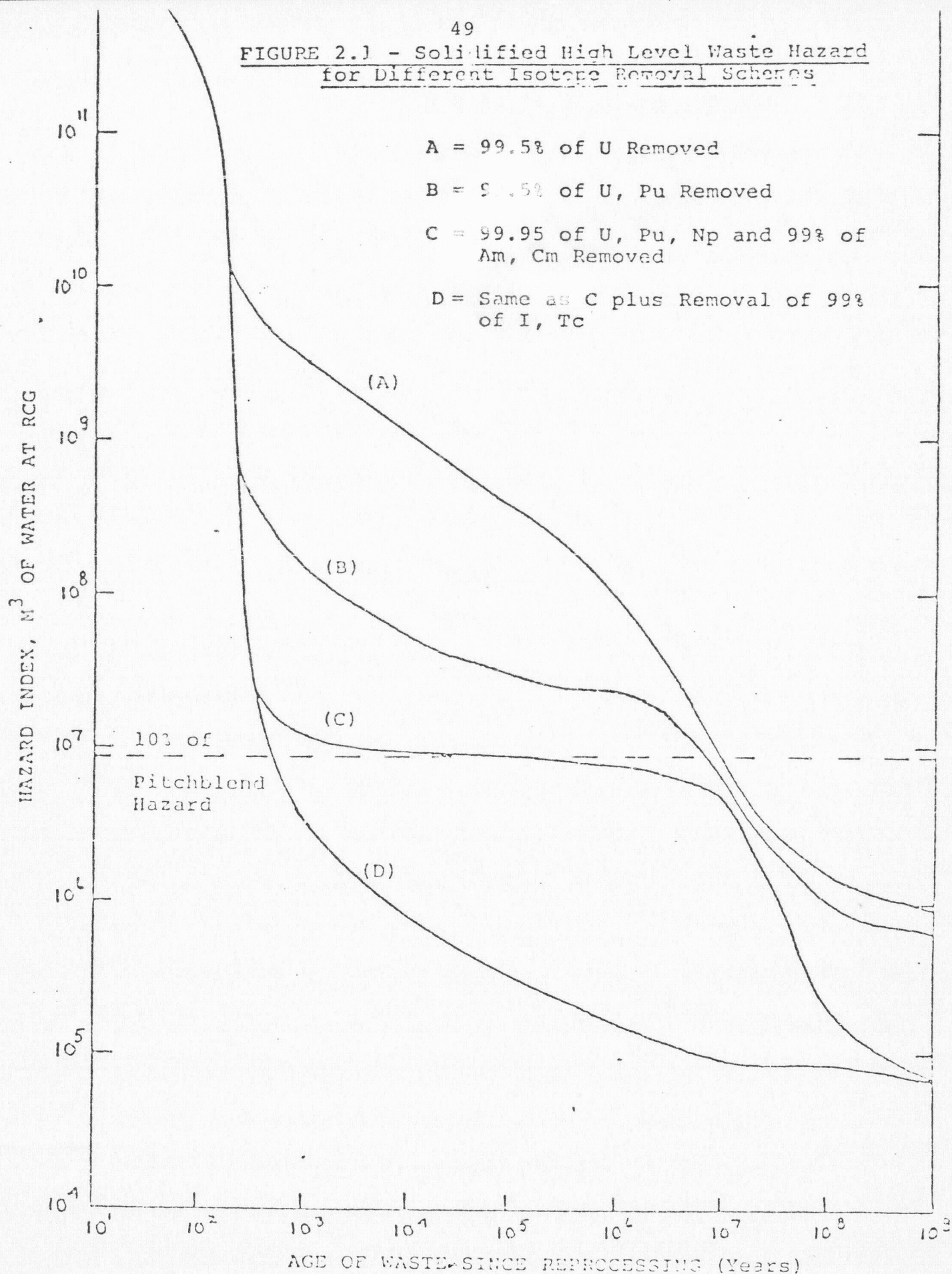
TRU waste contains numerous radioisotopes in much lower concentrations than HL waste. It is, however, especially troublesome because it is contaminated with transuranic elements, including plutonium, which have very long half-lives. Indeed, for a given amount of electricity generated with nuclear fuel, roughly the same amount of plutonium will ultimately emerge in TRU as in HL waste.*

Low-level radioactive waste that is not contaminated with transuranic elements is not as hazardous in the long-term as TRU waste. With respect to post-fission waste, it should be recognized that dividing low-level waste into TRU and non-TRU categories, or deciding what is "transuranic contaminated," is a question of judgment based on a complete interpretation of complex data. This report, as noted previously, focuses on HL and TRU wastes.

Post-fission waste originates from spent fuel assemblies that are routinely discharged from a nuclear power reactor. The irradiated fuel rods in these assemblies contain fission products, uranium, whose original uranium-235 content has been depleted by fission, and plutonium, which is produced by neutron capture in uranium-238

*Assuming that 99.5 per cent of the plutonium is extracted at the reprocessing plant, and recycled in fuel to reactors.

FIGURE 2.1 - Solidified High Level Waste Hazard
for Different Isotope Removal Schemes



From Kerry D. Dance, "High-Level Radioactive Waste Management: Past Experience, Future Risks, and Present Decisions," Paper prepared for the Resources and Environment Division of the Ford Foundation, April 1975, p. 21.

After discharge from the reactor, the materials constituting spent fuel assemblies move through a sequence of operations. Various categories of radioactive waste emerge at different points in the sequence. The operations are outlined briefly below and then discussed further.

Temporary Spent Fuel Storage

Irradiated fuel assemblies are temporarily stored in a cooling pond next to the reactor while radioactive decay proceeds sufficiently to permit safe transport. No plant for reprocessing spent fuel from commercial power reactors is presently operating in the U.S.. Consequently, the available storage capacity of existing cooling ponds at operating power reactors is rapidly decreasing. As a result, additional temporary storage capacity, either at various reactors or at a central location, will be required soon.

Spent Fuel Transport

After the cooling period, commercial spent fuel rods, which are still highly radioactive, are placed in massive containers for shipping from the storage pond at the reactor site to a reprocessing plant. In the case of military plutonium production, the production reactor and reprocessing plant are located on the same site.

Reprocessing

Following arrival at a reprocessing plant, the assemblies are disassembled and the spent fuel rods are chopped up. The residual mixture of fuel materials and fission products is dissolved and sent through the plant where a large number of chemical separations are performed. Plutonium and depleted uranium are recovered.

In the commercial nuclear power industry, the depleted uranium

can be re-enriched in the uranium-235 isotope, or it can be mixed with plutonium. In either case, the depleted uranium would be recycled in power reactor fuel. The recovered plutonium can be blended with uranium in mixed oxide fuel for recycling in existing light water reactors, or it can be stored for later use as fuel in breeder reactors.

In the weapons program, the recovered plutonium is used in the manufacture of nuclear warheads. In the naval propulsion program, it is unclear what subsequent use, if any, is made of the uranium and the relatively small amounts of plutonium which are recovered from reprocessing.

The radioactive waste from a reprocessing plant includes liquid HL waste, much larger volumes of liquid low-level waste (generally with no more than trace amounts of transuranic contamination), and solid waste -- cladding hulls, failed equipment, spent process materials, trash, etc, -- some of which contains appreciable amounts of the transuranic elements.

One plant for reprocessing commercial power reactor fuels was previously in operation at West Valley, New York. The plant has been temporarily shut down. The possibility exists that it may not be reopened. Another, larger commercial reprocessing plant is currently under construction at Barnwell, South Carolina.

Plants for reprocessing production reactor fuel for weapons are located at Savannah River, South Carolina, and Richland, Washington. The reprocessing of naval reactor fuel takes place at Idaho Falls, Idaho.

Temporary Storage

HL waste emerges in the course of reprocessing in liquid form. The liquid is stored temporarily in tanks adjacent to the reprocessing plant.

While HL waste emerges only as a liquid and primarily at the first plutonium and uranium extraction stage of the reprocessing plant, TRU waste emerges in various forms--liquid, combustible and non-combustible solids--at other points in the nuclear fuel cycle in addition to the reprocessing plant. The main sources of TRU waste are: the fuel cladding hulls and assembly structures from the head-end of the reprocessing plant; the residuals left from the conversion of liquid plutonium nitrate to plutonium oxide powder (commercial use) or to plutonium metal (weapons use); and the spent process material, general trash and failed equipment left from reprocessing, commercial mixed oxide fuel fabrication and military weapon component fabrication. TRU waste is collected, temporarily stored and sometimes mixed with other less toxic wastes at these various fuel cycle stages.

Waste Treatment

Depending on its composition, radioactive waste is treated in various ways: gases may be dissolved, liquids may be solidified, and solids may be incinerated (resulting in gas and less solid). In general, waste treatment is designed to make the waste easier or safer to handle subsequently, but every treatment method has its own set of costs and risks, and almost always results in the generation of secondary waste streams.

Waste Transport

Following treatment, radioactive waste is transported to

a location where it is more or less permanently disposed of. The importance of transport depends on the method of permanent disposition. No transportation is involved if HL waste is solidified in the bottom of a temporary storage tank and left there indefinitely. Long distance transport involving railroad or truck and ship is necessary for either seabed or ice sheet disposal.

Permanent Disposition

A wide variety of methods for permanent disposition of HL waste is being considered. The most practical appear to be either retrievable storage on or near the surface or geologic disposal in suitable formations either deep underground or under the ocean floor. Other methods under study are ice sheet disposal and, if partitioned, nuclear transmutation or extraterrestrial elimination of the extracted long-lived actinides.

It is generally stated that no method for permanent HL waste disposition has been adopted yet. It could be argued, however, that in the case of the majority of military HL waste a decision may effectively already have been taken and implemented. In this case, liquid waste stored temporarily in tanks has been solidified in situ. It now appears that the task of exhuming these solids will be very difficult and costly, and for this reason the waste might be left there indefinitely.

Some TRU waste has been disposed of, essentially irretrievably, in ocean dumping grounds. Other waste has been deposited in shallow burial grounds. Not all of these land burials will permit retrieval at reasonable cost. The question of the permanent disposition of TRU waste to be generated in the future is unresolved.

Radioactive Waste Quantities

The following is a brief review of the amounts of radioactive wastes that have already been generated in the U.S., together with some predictions of how these amounts will increase over the next twenty to thirty years. The discussion is presented so that it is possible to compare existing quantities of military waste with those produced in the commercial nuclear power program.

High-Level Waste

As a result of military activities from the middle 1940's to the present, the former AEC and its successor, ERDA, have generated about 215 million gallons of liquid HL waste.* Solidification programs have been in operation for some years at the three sites at which this waste is stored: the Hanford reservation near Richland, Washington, the Savannah River Plant in South Carolina, and the Idaho National Engineering Laboratory, near Idaho Falls in Idaho. As a result, over 80 percent of the original liquid has been solidified. The accompanying volume reduction has meant that, as of January 1, 1976, there was an HL waste inventory of about 75 million gallons, half of which was in solid form.

More than 70 percent of this waste is currently stored at Richland, with about 25 percent at Savannah River and 3 percent at Idaho Falls. It is estimated that by the early 1980's when most

*With the passage of the Energy Reorganization Act of 1974 the former AEC was fissioned into two parts--NRC (nuclear regulation) and ERDA (nuclear and non-nuclear energy research, development and demonstration).

of the waste will have been solidified, there will be a total of more than 450,000 tons of residual HL solids at these three sites.

In contrast, the commercial nuclear power industry has until now only produced 600,000 gallons of HL waste. All of this waste is still in liquid form and is stored at the site of the Nuclear Fuel Services reprocessing plant at West Valley, New York.

Currently, HL waste from ERDA programs is being generated at an annual rate of 7.5 million gallons, but it is not known how long this rate of production will continue. Predictions must be based upon an assumed plutonium demand rate for nuclear weapons. Predictions of future generation rates of commercial HL waste must be based on assumed nuclear power growth rates, and are therefore also subject to considerable uncertainty. It is estimated, however, that the commercial nuclear power industry in the U.S. will have generated 60 million gallons of liquid HL waste by 2000, and that not until 2020 will the commercial power industry have produced as much liquid HL waste as has already been produced by U.S. military programs.

According to recent calculations, the volume of all the solidified HL waste produced by the commercial nuclear power industry through 2000 will be equivalent to a cube 70 feet on each side, whereas the equivalent cube for the military HL waste will have a side measuring approximately 220 feet. Of course, this calculation should not be interpreted to mean that these volumes are all that will be required to store the waste. Much larger storage volumes will be necessary. But the calculation does indicate that the main problem in safely managing HL waste will be one of confining the radioactivity, rather than of finding

enough storage space.

A volumetric comparison alone is not sufficient when comparing military and commercial wastes. One ton of spent fuel from a plutonium production reactor produces a larger volume of HL waste than does one ton of spent commercial power reactor fuel. Furthermore, fuel in plutonium production reactors only receives about a tenth as much irradiation exposure before discharge as commercial power reactor fuel. The amount of radioactivity in spent production fuel is therefore correspondingly lower. Although such information is classified, and in fact may not even be known, one estimate is that existing military HL waste contains 5 billion curies of radioactivity. Nuclear power projections indicate that the inventory of radioactivity in commercial HL waste will not reach that level until the 1990's.

The conclusion that clearly emerges is that the quantity of military HL waste far exceeds the amount generated by the commercial nuclear power industry. Furthermore, this discrepancy is likely to continue at least until the end of the century.

TRU Waste

Through June 1974, 42 million cubic feet of military low-level waste had been buried at five principal land burial sites. Through 1973, over 9 million cubic feet of commercial low-level waste had been buried at six commercially licensed sites.

As of April 1970 there was no distinction made between TRU and non-TRU waste for burial purposes. At that time, TRU waste was defined as waste with a concentration of transuranic activity

greater than 10 nanocuries per gram.* It was also decided that all TRU waste subsequently delivered to Federal burial grounds should be stored above ground in retrievable form. About 952 kilograms of plutonium are contained in the military TRU waste buried at the five major Federal burial sites. Of this amount, 740 kilograms were buried before 1970, and the remaining 212 kilograms have been stored retrievably. Through 1973, TRU waste containing some 80 kilograms of plutonium has been buried at the six commercial sites. There is likely to be no further shallow land burial of commercial TRU waste if proposed regulatory changes are adopted. All future military and commercial TRU (and that which is stored presently) will probably be disposed of more carefully.

Military activities are currently generating low-level solid waste at the rate of 1.3 million cubic feet per year. (The fraction of this total generation rate that is TRU contaminated has not yet been established.) It is expected that this rate will gradually decrease in the future. Recent projections of commercial waste generation indicate that by 2000 there will be over 50 million cubic feet of TRU waste, including about 1 million cubic feet of spent fuel cladding waste.

In addition to the above quantities, unspecified amounts of low-level waste, military and commercial, have been placed in cannisters and discharged into the sea at U.S. dumping sites off

*One nanocurie = one billionth of a curie.

the Atlantic and Pacific coasts. The proportion that is TRU contaminated is unknown. Ocean dumping of U.S. low-level waste was suspended in 1970. However, other countries are continuing this practice.

The existing amount of military TRU waste thus exceeds the current amount of commercial waste, but the dominance is not as great as in the case of HL waste.

Radioactive Waste Leakage

AEC, ERDA's predecessor as manager of military waste, intentionally discharged or accidentally released large quantities of HL and TRU waste. Between 1956 and 1958, about 31 million gallons of radioactive waste containing 1.3 million curies (excluding strontium and cesium, but including plutonium) was poured into soil on the Hanford reservation. In addition, the Hanford Plutonium Finishing Plant has discharged liquid effluent containing large quantities of plutonium to sub-surface trenches that are not isolated from the soil. Indeed, in the case of one particular trench, over 100 kilograms of plutonium was released in this way, creating a potentially severe radiological hazard and the possibility of a spontaneous fission reaction.* Roughly 740 kilograms of plutonium have been buried irretrievably at five principal Federal burial sites. The liquid HL waste tank farms at the Hanford reservation have developed eighteen leaks amounting to the loss of over 430,000 gallons of waste.** The largest leak so far occurred in 1973 and

*Note that the HL waste generated by a typical U.S. power reactor (i.e., a 1000 MWe light water reactor) during its entire operating lifetime (about 30 years) would contain about 30 kilograms of plutonium.

**The 430,000 gallons contained 50,000 curies of radioactivity including 4 curies of plutonium.

caused the escape of 115,000 gallons of HL waste into the surrounding soil. Eight leaks have occurred at the Savannah River Plant, but only one of about 100 gallons is known to have resulted in contamination of the surrounding soil. These leaks have neither killed nor injured any one to date. Nonetheless their hazard will remain for hundreds of thousands of years.

Potential Causes of Harmful Effects

Many events may cause the release of radioactivity from waste management activities. They can be classified as accidents due to human failure, intentional acts, or natural phenomena.

Accidents can be categorized according to their causes--usually either inadequate construction or improper operation. An example of the first category would be the leaks which occurred in carbon steel, military liquid HL waste tanks. The surrounding ground and the food chain will delay, distribute over time, and, if there is enough time, instigate the actual biological consequences of these leaks.

Intentional acts against waste management facilities may be characterized as acts of either warfare or sabotage. For instance, the temporary HL waste tanks adjacent to a reprocessing plant might be sabotaged for the purpose of achieving long-term local contamination. Surface waste management activities might be targeted with nuclear weapons to increase the degree, duration and coverage of contamination after a nuclear war, but the same weapons would be much more effective if they were used initially in the destruction of cities or military targets.

Finally, various natural events can abruptly or chronically initiate releases of radioactive materials to the environment. Abrupt events include floods, earthquakes, volcanoes, and, conceivably, meteors. They may result in immediate environmental contamination or they may expose the final waste form to slow but continual degradation and subsequent seepage into the biologically active media of soil and water. In chronic release scenarios, the essential question is how much waste will reach the soil or watershed during its period of toxicity. Chronic events include the possible shifts of water tables and river courses, the glacial erosion caused by Ice Ages, slow but continual geologic faulting, leaching processes, and surface ice flows and underground lake migration in Antarctica.

Conclusions

From the preceding outline of the basic facts of the post-fission radioactive waste problem in the U.S., several conclusions may be drawn:

1. As a consequence largely of nuclear weapons programs, the U.S. government has already committed itself to a radioactive waste management responsibility of major proportions which is still growing.
2. Because of the maturing nuclear power industry, the U.S. is generating a rapidly increasing volume of radioactive waste. The bulk of this waste remains in the form of spent fuel elements in temporary storage ponds at commercial reactor sites.
3. Radioactive wastes must be safely managed to prevent contamination of the biosphere and possible radiological hazards to life.

4. Thus far, the U.S. government's record of management has been marred in a sufficient number of instances to be a cause of concern.

* * *

An inevitable legacy of our nuclear age, radioactive waste constitutes a potential Nth century hazard.

Chapter 3

RADIOACTIVE WASTE MANAGEMENT

From chapter 2, we have seen that post-fission radioactive waste is a growing problem with both immediate and long-term ramifications. The problem requires enlightened, far-sighted management.

This chapter, therefore, focuses on radioactive waste management. It does so in a strategic, not tactical sense. We consider key decisions, rather than day-to-day operations. Of course, management involves a decisional process that carries the radioactive waste problem forward from the present into the future. As we shall see, radioactive waste management is a paradigm of decision-making under uncertainty.

The purpose of this chapter is to present in a coherent manner the strategies that are under consideration for the management of post-fission radioactive waste. The discussion is structured to provide readers with an understanding of how the sequences of key decisions that constitute waste management strategies are inter-related. It is important to determine the constraints each decision imposes on the available technological options. It is also important to consider the risks, costs and benefits associated with the various strategies. Our task is to identify the strategies and the major issues which they raise. We do not attempt quantification. Therefore, the analysis which follows is intended to provide a framework for analyzing the problem that is sufficiently flexible to cope with

the uncertainties involved, yet rigid enough to provide guidance for waste management decision-making.

Overview

The main waste management strategies currently available for commercial and military HL and TRU wastes are shown in figures 3.1 and 3.2. The strategic decisions have been highlighted. The sequences of decisions correspond chronologically to the actual material flows (for example, from reactor spent fuel discharge to permanent disposal of HL waste in salt deposits). This is not necessarily the order in which the strategic decisions need or should be made. The decisional interdependence of waste management planning, unlike the flow of the waste itself, does not move in one direction through time. For example, the selection of a method of permanent disposition may influence the selection of the form of solidified waste and possibly the selection of waste composition. Such decisional interdependence is a recurrent theme.

Military and commercial management are separated. In the short term, the technologies required to deal with these wastes of different origin are significantly different, particularly in the high-level category. Furthermore, a number of important early decisions, starting with the initial decision to reprocess, have already been made in the case of military waste, whereas almost all of the major issues concerning commercial waste generation and management (with the notable exception of the decision to develop a substantial nuclear-electric generating capacity) have yet to be settled.

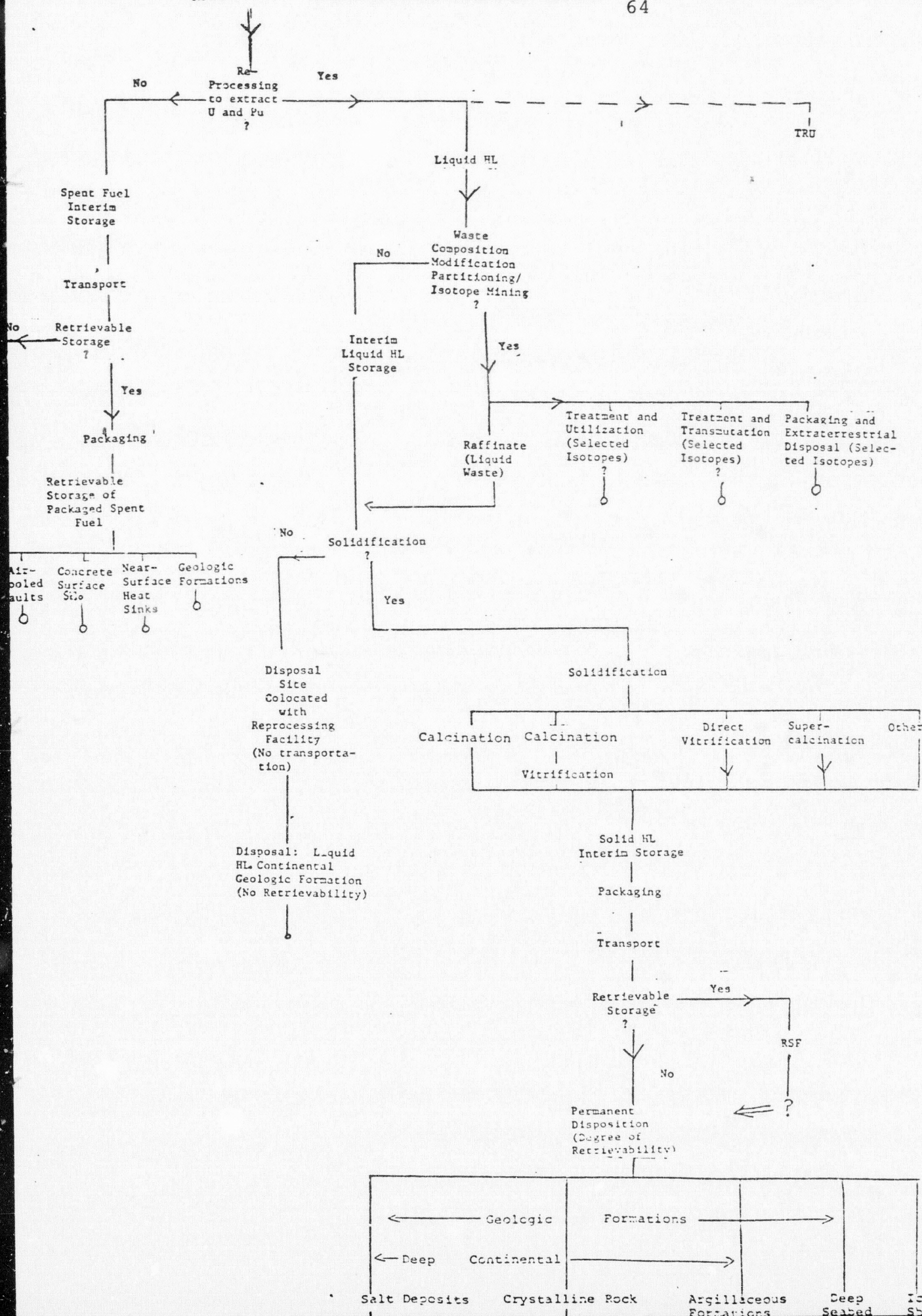


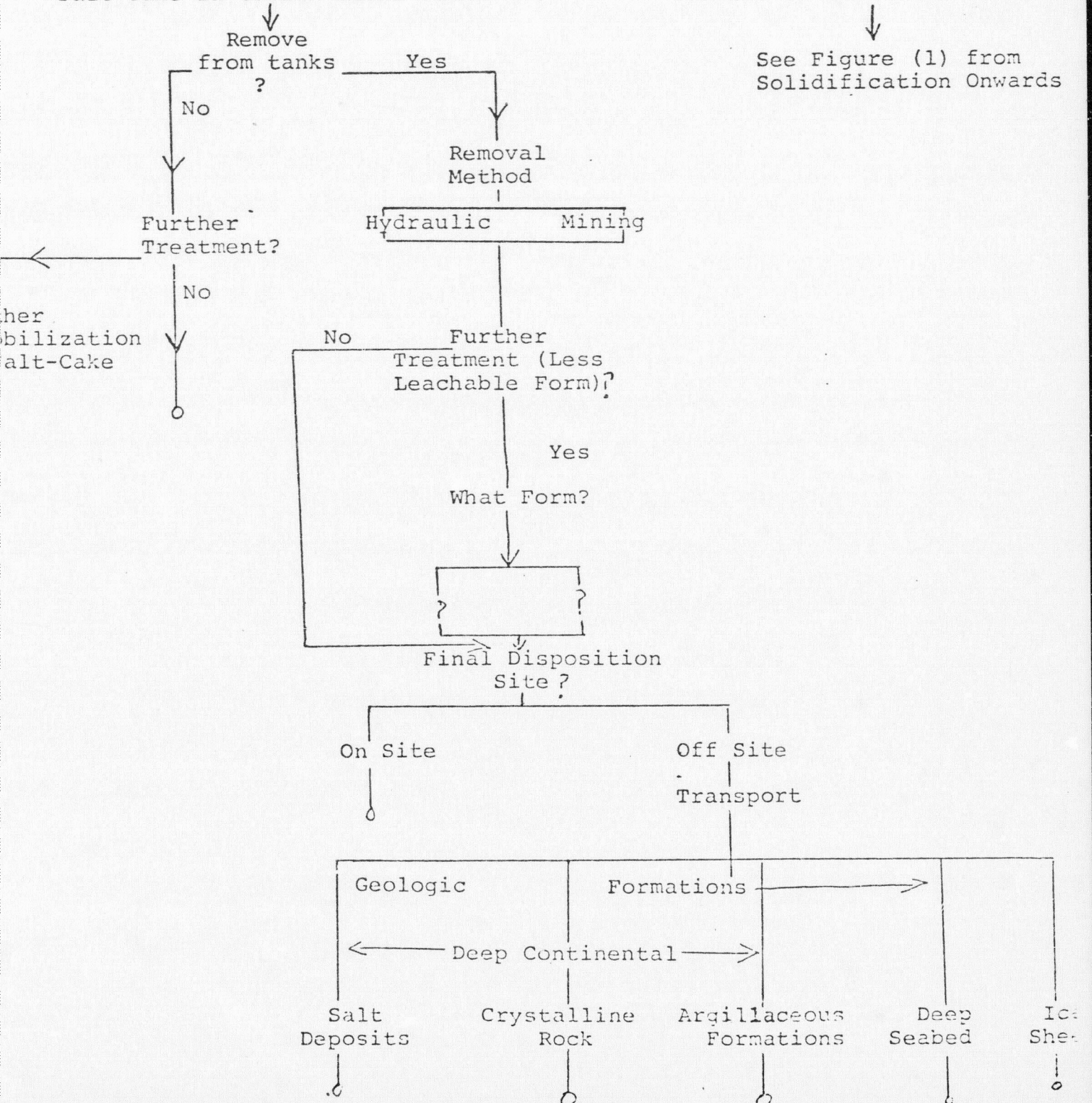
FIGURE 3.2ACCUMULATED MILITARY WASTE MANAGEMENT STRATEGIES

- Savannah River and -
Hanford Waste (Pu
Production)

- Idaho Waste -
(Naval Propulsion
Spent Fuel)

Salt Cake in Carbon Steel Tanks

Calcine in Stainless Steel Tanks



Because of the future importance of nuclear power and the unresolved nature of the accompanying post-fission waste management decisions, it will be illuminating to consider in the following order the general implications for nuclear power development of reprocessing, the storeaway/throwaway waste management alternative if there is no reprocessing, and the radioactive waste implications of reprocessing. The stage will then have been set for a discussion of the management of commercial HL, military HL, commercial TRU and military TRU wastes.

Reprocessing: Implications for Nuclear Power Development

The first decision is whether to reprocess spent fuel from commercial power reactors. Since the reprocessing decision profoundly affects the whole future development of nuclear power, waste management issues in this context must be kept in perspective and neither exaggerated nor lost from view.

The present economic incentive for reprocessing spent power reactor fuel is to extract uranium and plutonium so that these fissionable materials can be recycled as fuel in commercial power reactors. It is not clear that the value of the fissionable material extracted from spent fuel will outweigh the cost of reprocessing. Uncertainty arises from a number of sources.

First, the value of plutonium and uranium recovered through reprocessing depends on the price of natural uranium. At the present time, the extent of uranium ore resources is not well known. Although the selling price of uranium ore has been increasing rapidly, future price trends are highly uncertain and

are likely to be affected by other factors in addition to the availability of uranium ore.

The second major source of uncertainty is the cost of spent fuel reprocessing and the cost of fabricating fuel containing mixed plutonium and uranium oxides. Mixed oxide fuel fabrication is much more expensive than the fabrication of the low-enriched uranium fuel used currently in light water reactors. Two types of uncertainty are associated with these costs: (1) Neither reprocessing nor mixed-oxide fuel fabrication has reached the stage at which it can be called a "mature" industry. Cost estimates for commercial plants have to be made by extrapolation from smaller scale demonstration-type plants. (2) The regulatory requirements for these plants have not yet been established. In particular, the safeguards against theft or diversion that must accompany plutonium through all stages of recycle are undetermined.

Therefore, the calculations often used to estimate the economic feasibility of spent fuel reprocessing and plutonium and uranium recycle cannot provide a conclusive answer to the question of whether or not to reprocess.

To put the decision in perspective, it is necessary to include its long-term implications. Many of the important implications for waste management are essentially long-term and will be dealt with separately. The implications for the future of nuclear power are merely outlined here.

A decision not to reprocess spent fuel, if adhered to, will mean that nuclear power will only play a short-term, interim

role in meeting U.S. energy demands over the next few decades. The duration of that role would be limited by the extent and quality of uranium ore deposits known and yet to be discovered.

The present generation of commercial power reactors, the light water reactors (LWRs), use slightly enriched uranium fuel that contains 2-4 percent uranium-235 and the remainder uranium-238. Fission of uranium-235 in present LWRs is accompanied by the conversion of some of the uranium-238 isotope into plutonium which is easily fissioned, but LWRs are relatively inefficient converters. Without reprocessing, therefore, the possibility of fission is limited to a relatively small fraction of the uranium-235 contained in fresh fuel and that fraction of the plutonium produced from the initial inventory of uranium-238 which fissions before the fuel becomes poisoned with fission products and must be discharged.

If the decision is made to reprocess spent fuel and to allow the recycle of uranium, but not plutonium, then the uranium resource constraint will still basically apply. The recycled uranium would add at most about 20 percent to the energy that could ultimately be produced. If, however, the decision is to permit spent fuel reprocessing and to allow recycling of both uranium and plutonium in existing LWRs, the recycled plutonium would add perhaps an additional 25 percent to the energy output from nuclear power. Thus, reprocessing and widescale uranium and plutonium recycling in the existing type of commercial nuclear power reactors would stretch the lifetime of nuclear fission power perhaps a decade or two, but nuclear power would remain an interim energy option.

The future of nuclear power as a long-term energy option hinges primarily on the successful development and commercialization of a plutonium breeder reactor, and such a breeder necessarily requires large-scale reprocessing of spent fuel. Plutonium breeder reactors use mixed plutonium-uranium fuel surrounded by a uranium blanket. Fission of plutonium in a breeder reactor results, through uranium-238 neutron capture and subsequent conversion, in the production of more plutonium than is consumed. In short, a breeder reactor is a much more efficient converter of plentiful uranium-238 into plutonium than is a light water reactor.

A plutonium breeder of the liquid metal cooled, fast neutron reactor type (LMFBR) is the long-term technological option being currently pursued as the highest priority in the U.S. and by every other country with a major nuclear power program. The breeder reactor development programs in a number of other countries including France, Great Britain, the Federal Republic of Germany, and the Soviet Union are currently on a more advanced schedule than the U.S. program. The U.S. reprocessing decision must be seen in this dynamic worldwide context.

It is possible to construct a strategy in which spent fuel is reprocessed and the plutonium is not recycled to existing LWRs, but rather stored for an interim period and used subsequently in plutonium breeder reactors. This may well occur in Europe because of the earlier introduction of breeders into commercial use. In the short-term, the effect of such a decision on the U.S. nuclear industry would be significantly different from a decision to re-

cycle plutonium immediately to LWRs. In the long term, and particularly in the long-term effect on radioactive waste management, the difference will be quantitatively marginal and qualitatively non-existent.

There is one possible way in which nuclear power might be developed which would avoid both the uranium resource constraint and a plutonium breeder reactor economy. This would involve a fundamental shift from the uranium-plutonium fuel cycle, on which the world wide nuclear power industry has been largely based, to the thorium-uranium-233 fuel cycle. The technical and economic feasibility of such a radical mid-course shift needs further study before it can be seriously considered. If the main reasons for wishing to escape from the plutonium economy are its diversion and routine handling implications, it is by no means clear that the situation would be improved by long-term reliance on a uranium-233 economy. Uranium-233 is a fissionable material which is about as useful for making nuclear explosives as plutonium, and it would be accompanied at all stages in the fuel cycle by uranium-232, an isotope which decays to form isotopes that emit highly penetrating gamma radiation.

The preceding paragraphs have shown that the way in which nuclear fission is most likely to become a long-term energy option is through the successful development of a plutonium breeder reactor. The prospect of a large, mature nuclear power industry based on plutonium raises profound issues for society aside from the energy that will be produced. Very large amounts--tens of thousands of kilograms--of plutonium will emerge annually from

reprocessing plants, flow through fuel fabrication facilities, and be recycled into breeder reactors. Can a reactor which uses liquid sodium as coolant and fast neutrons for fission be made safe? Can toxic plutonium be managed in reprocessing and fuel fabrication operations without undue risk to the health of workers? Can large flows of plutonium--a few kilograms of which are sufficient for a nuclear explosive--be managed so that no significant amounts are stolen?

These issues are in addition to the long-term radioactive waste implications of a plutonium economy. All of them are imbedded in the basic reprocessing decision. With these overarching considerations in mind, we shall now examine in greater detail the waste management implications flowing from the reprocessing decision.

No Reprocessing: The Storaway/Throwaway Alternative

As mentioned earlier, when spent fuel is discharged from a power reactor it is stored at the reactor site in water-filled ponds. The water acts as a heat transfer medium for the radioactive decay heat that must be removed from the fuel, and also provides shielding and a secondary containment barrier for any radioactivity that the fuel cladding fails to contain.

If the decision is made not to reprocess, the spent fuel cannot be left where it is for very long. Water basin storage of unpackaged spent fuel is an unreliable method of isolating the contained radioactivity for periods longer than a few years, primarily because of deterioration in the quality of the containment provided by the spent fuel cladding. Economies of scale are likely to show that long-term storage of spent fuel should be carried out at one or more central locations rather than at each reactor. Hence, after a period of cooling at a reactor site, spent fuel assemblies will be shipped in specially designed casks to these storage facilities. There they will be removed from the casks and specially packaged to provide an extra degree of containment. Possibly this packaging will occur after a further period of interim storage. For spent LWR fuel, there is likely to be a period of 3-5 years between reactor discharge and packaging so that the provision for radiation shielding and heat removal in the package design is made easier.

The question of whether to store the fuel retrievably or dispose of it irretrievably arises at this stage. We shall not discuss this issue, except to point out that despite the judgment that produced the original decision not to reprocess, it seems unlikely that an irretrievable disposal method for spent fuel will be chosen in

a society acutely conscious of energy shortages. Irretrievable disposal would deprive future generations of the opportunity to resurrect a long-term nuclear option using the spent fuel inventory of fissile material.

Various methods for retrievable storage of packaged spent fuel have been proposed, including water-cooled basins, air cooled vaults, concrete surface silos, near surface heat sinks and geologic formations. The technological requirements for geologic storage are similar to those for the storage of HL waste in geologic formations. These will be discussed later. Any method adopted must contain the radioactivity in the fuel and protect the fuel against mechanical, chemical or thermal damage. It must also provide a safe, subcritical arrangement for the fuel so that the risk of a fission chain reaction is acceptably low. This environment must be maintained under normal conditions and the storage facility must be designed for a "maximum credible accident", such as the kind of natural catastrophe most likely in the area of the site.

An integral part of the design of the storage facility will be the provision for retrievability. It is unclear as to how long it is feasible for a facility to retain this characteristic. A period of a hundred years is often mentioned as being practical for near-surface or surface engineered storage. However, retrievability is a feature that will not disappear overnight. Instead, inevitable deterioration of the various barriers will gradually make the recovery process more and more difficult. Therefore, in the case of a water-cooled basin, air-cooled vault, concrete surface silo or near-surface heat sink, the spent fuel would need to be removed before storage becomes "irretrievable." For geologic storage concepts,

however, this may not be necessary. It should also be remembered that over the life of the storage facility, the perception within society of what may or may not be retrievable is likely to vary with the levels of technological ability and the incentives for retrieval.

One result of reprocessing and recycling plutonium is that only about one hundredth of the plutonium that would otherwise have to be stored in spent fuel is discharged in the HL and TRU waste. The plutonium in an unprocessed spent fuel assembly would take almost two hundred thousand years longer to decay to any given level than the plutonium discharged in the HL and TRU waste that would otherwise be generated by reprocessing that assembly and recycling the recovered plutonium. The implication sometimes drawn from this is that reprocessing and fissioning of 99.5 percent of the plutonium is advantageous from a long-term waste management perspective. This may be true, but the argument is not so simple. For instance, although at any given time the activity of the plutonium in the spent fuel is about two hundred times greater than that in the HL waste, if the performance of a storage repository is gauged by the length of time for which it can isolate radionuclides from the biosphere, and a period of a million years is set as a suitable "criterion" for HL waste, would we really be significantly less confident about finding a repository that could isolate radionuclides for an extra two hundred thousand years?* The same argument applies to TRU wastes.

*Rephrasing the question slightly, it is valid to ask if there would be more confidence in the ability of a repository to isolate wastes for 1 million rather than 1,200,000 years.

Furthermore, it has already been noted that a decision to reprocess and recycle plutonium would allow nuclear fission to become a long-term energy option. Therefore, rather than making the very long-term comparison on the basis of a single assembly, it would perhaps be more reasonable to compare the implications of storing the spent fuel accumulated during a short-term nuclear option with those of storing HL and TRU waste generated during the deployment of a long-term breeder-based nuclear power industry.

Reprocessing: The Closed Fuel Cycle

Having outlined some of the important issues arising from a decision not to reprocess, we now turn to the radioactive waste implications of the other alternative. The discussion continues under the assumption that a decision to reprocess spent fuel is accompanied by a decision to recycle uranium and, sooner or later, plutonium. From a waste management perspective, this route could be viewed as increasing the complexity of subsequent management operations. Before reprocessing, almost all the fission-product and trans-uranic radionuclides are retained by the cladding within the spent fuel assemblies. Reprocessing involves chopping up the fuel (with the release of trapped fission product gases), leaching out the spent fuel core material from the cladding hulls with nitric acid, and subjecting the fuel solution to a series of chemical extraction stages designed to recover and purify uranium and plutonium. Each of these operations results in additional dissemination of the radionuclides originally contained in the spent fuel and the consequent generation of many waste streams with different physical forms and chemical compositions. However, it must be remembered that during reprocessing almost all of the by-product plutonium is extracted. Plutonium is extremely radiotoxic, has a half-life of about 24,000 years, and is a major contributor to the long-term risk from post-fission wastes. After extraction it may be recycled and fissioned into less hazardous fission products. Some of the long-term implications of this were mentioned at the end of the previous section.

A brief review of the HL and TRU waste streams generated during reprocessing follows:

After the chopping and leaching, the pieces of fuel cladding

(hulls) remain undissolved. In addition, residual traces of undissolved spent fuel remain on the cladding hulls. Up to 0.1 percent of the fission products and actinides are trapped in this way. The chop and leach operation results in the release of gaseous wastes.

Plutonium and uranium are extracted from the nitric acid fuel leach solution into an organic solvent. The aqueous solution remaining after this first cycle co-extraction of uranium and plutonium is the principal component of the HL waste stream. The major constituents of HL waste are the fission products and the actinides. Over 99 percent of all the non-volatile fission products contained in the spent fuel appear in the HL waste. It is expected that approximately 0.5 percent of the uranium and plutonium originally contained in the spent fuel will not be recovered. Thus it will appear mainly in the HL waste stream, together with almost all of the other actinides (the important ones being neptunium, americium and curium.)

The properties that are important in the subsequent handling of the HL waste stream are the thermal power and the curies of radioactivity generated by decaying fission products and actinides, and the neutron emission rate from spontaneous fission. It should also be noted that the chemical form of the liquid HL waste stream is a nitric acid solution.

Finally, solid TRU waste in addition to the cladding hulls and assembly pieces emerges during the course of reprocessing. This waste may be divided into a number of different categories: combustible trash; non-combustible solids; slurries, sludges and resins from water clean-up, and filters from gas clean-up.*

*Large volumes of low activity aqueous waste are also generated during reprocessing. Only trace quantities of transuranics appear in this waste stream.

At this point, a brief digression is appropriate. Modifications can be made to existing procedures or equipment that facilitate the management of wastes generated during reprocessing. These may not, strictly speaking, be considered as waste treatment technologies since, rather than actually handling waste streams, the waste management problem is affected in its gestation period. The major thrust of improvements currently being considered is to develop "low chemical additive" flowsheets, and wherever possible to avoid unnecessary secondary waste streams. The quantity and variety of wastes generated is thus minimized and the chemical composition expedites subsequent operations.

This general principle -- prevention rather than correction -- may be extended beyond reprocessing to all sources of radioactive wastes in the fuel cycle. It is impossible to avoid completely the generation of waste as long as there is fission, but much can be done to affect the type of waste that is generated.

Commercial HL Waste

Now let us focus on commercial HL waste. The structure of the following discussion corresponds to the decision scheme in Figure 3.1 (on page 3-3). It should be re-emphasized that the order in which these decisions are actually made will not necessarily be the same as the order in which they are presented here.

Radioisotope Extraction

After reprocessing, the next strategic decision is whether or not to alter the chemical composition of the HL waste that emerges. Any operation which changes the waste composition will take place in the liquid phase. This step will therefore almost

certainly precede waste solidification, since performing further radioisotope extraction operations directly after reprocessing seems more sensible than first solidifying the waste, subsequently redissolving it and then changing the waste composition.* However, in the future a revised sequence may, for as yet unknown reasons, become attractive.

Both radioisotope extraction and solidification will occur at the reprocessing plant site since the transportation of liquid HL waste is prohibited for safety reasons. Such a prohibition is appropriate since the risks of transport in liquid form outweigh the gains, if any, of waste treatment off-site.

Why should the HL waste composition be altered after it emerges from the reprocessing plant? Two different rationales are proposed. First, the removal of certain radioisotopes from the waste may facilitate subsequent waste storage and disposal. Extraction for this purpose is generally referred to as "waste partitioning." Second, the waste contains isotopes that could be recovered and used in other applications. Extraction for this purpose may be called "isotope mining." Of course, waste partitioning and isotope mining are not mutually exclusive, since an isotope might, for example, be partitioned to reduce long-term risks from the waste and might also have commercial value.

With respect to partitioning, we observe that spent fuel reprocessing technology is governed by the law of diminishing returns. With available technology, it is not likely that it will pay to extract more than about 99.5 percent of the uranium and plutonium from

*It may be necessary to store the liquid HL waste temporarily to allow further radioactive decay before the extractions take place.

the spent fuel. The extra cost of more efficient extraction will probably more than offset the value of the energy in the fuel material recovered by the effort. Therefore, as previously noted, the HL waste contains about 0.5 percent of the plutonium and uranium contained in the spent fuel as well as almost all of the fission products and transuranic actinides apart from plutonium. In general, the actinides take a very long time to decay to harmless levels -- on the order of a million years, whereas the fission products lose almost all of their radioactivity after about a thousand years. This is an oversimplified picture, since some fission product isotopes (principally iodine-129 and technetium-99) have extremely long half-lives and thus remain a potential hazard for as long as the actinides.

The rationale for partitioning is as follows: if HL waste can be divided into fractions according to half-life, the flexibility of subsequent waste storage and disposal operations will be increased, since it will then not be necessary to isolate all the waste from the biosphere for the length of time dictated by the toxic lifetime of the longest-lived radionuclide present in the unpartitioned stream. Therefore, if the actinides and perhaps the long-lived fission products can be partitioned from the HL waste, the residual fission product waste will probably need to be isolated from the biosphere only for about one thousand years. This is a long time in human history, but a relatively short time in geologic terms. It is short enough to be confident about the continuing integrity of the geologic formation in which the waste is stored.

The long-lived fraction partitioned from HL waste might then be eliminated. Transmutation and extra-terrestrial disposal have been proposed as elimination methods. The former essentially would

convert long-lived radionuclides into shorter-lived ones, and the latter would provide an isolation method of cosmic proportions. Both alternatives are still in an early stage of development and are not likely to play more than a peripheral role in waste management planning in the near future.

Strontium-90 and cesium-137 have also been suggested as candidates for partitioning from HL waste, since these isotopes contribute about 90 percent of the activity in the spent fuel after a few years of cooling and continue to dominate for the first several hundred years. During this time they are the most important heat emitters, dictating the thermal design of the waste storage repository. However, removal would not materially reduce the potential hazard posed by these radioisotopes since it is impractical to apply either nuclear transmutation or extra-terrestrial disposal methods to them.

Methods to partition the long-lived radionuclides with sufficiently high extraction efficiencies have not yet been demonstrated, but the indications are that if they are feasible they will also be expensive. The same holds for the additional fuel cycle operations that would be necessary for the partitioning/transmutation option and the space technology required for extra-terrestrial disposal. Furthermore, these new steps would introduce new short-term, operational risks and would also generate new secondary waste streams.

Assessment of the partitioning/transmutation and partitioning/extra-terrestrial disposal options will be a difficult task, since it involves comparing the potential benefits of a reduction in risk that will not begin to take place for almost a thousand years with the increased costs and short-term risks of the technologies that must be implemented if this is to be achieved.

Turning to isotope mining of HL waste, the production of isotopes as by-products of the nuclear power program will far exceed the amounts required for applications in most cases. The management of the residual waste will be effectively unchanged. Furthermore, use of the radioactive isotopes that are mined defers, but does not eliminate, their contribution to the waste problem, since they must eventually be disposed of unless they have decayed to harmless levels during the period of their use. Indeed, waste management may be complicated further, since the radiotoxicity (and sometimes the chemical toxicity) of these isotopes requires their use to be tightly controlled.

Waste Solidification

Whether or not some isotopes are extracted after reprocessing, the liquid HL waste stream is a hazard if it is not handled and processed properly. Solidification immobilizes the waste and reduces its volume, thereby diminishing the potential hazard in liquid HL waste.

Current regulations require solidification to take place no later than five years after the liquid HL waste is generated at a commercial reprocessing plant. A number of different types of solidified product are proposed, each of which can be prepared by a number of different chemical processes. Despite this proliferation of means and ends, solidification technology is already quite well developed, and some of the processes have been extensively applied. Calcination has been used to solidify some U.S. military HL waste for over a decade. Calcined waste is, however, quite leachable. For this reason it is probably unsuitable for long-term waste disposition. Methods to produce

vitricified waste have therefore been developed. The final product of vitrification is a glassy matrix containing waste. It is highly leach resistant and is regarded as being well-suited for long-term isolation of waste. The technology for other solidified waste forms, for example, supercalcine, metal matrix, glass ceramic and coated pellet, is at an earlier stage of development.

It has been suggested that, instead of solidification, HL waste might be disposed of simply by injecting it in liquid form into suitable rock formations. The decay heat from the waste would be sufficient to melt the surrounding rock. As the waste continued to decay, the molten rock-waste mixture would eventually solidify, thus immobilizing the waste in a stable, non-leachable form. This in situ melting concept for liquid HL waste disposal could only be utilized if the reprocessing plant was sited above a suitable geologic formation, unless the present regulations are changed to permit transport of liquid HL waste. The concept is not generally favored, perhaps because it is so unequivocally irretrievable from the outset. It is worth noting at this stage that the in situ melting concept has also been proposed for the disposal of solid HL waste. Similar considerations apply, except that in this case, collocation of the reprocessing plant and disposal site would not be required.

Retrievable Storage

The next major decision concerns retrievable storage of solid HL waste in surface or near-surface storage facilities. After the waste is solidified and suitably packaged, it can be transported either to a permanent storage or disposal site directly, or first to an interim storage facility and then, at some later date, to a

final resting place. Retrievable storage concepts place the responsibility for waste isolation on man-made systems maintained under appropriate surveillance. As noted previously for storage of unprocessed spent fuel, "interim" generally is used to mean a period of up to 100 years.

The idea of retrievable storage of HL waste has had a checkered history. The present situation is that an earlier decision to construct an interim surface storage facility for the waste has been reversed and it is now planned to transport solidified HL waste directly to a permanent storage/disposal site. However, the retrievable storage concept may still be revived. Water-cooled basin, air-cooled vaults and concrete surface silos have all been proposed as storage methods.

Retrievable storage of HL waste allows time for the development of new, improved permanent disposition technologies. Actinide partitioning-elimination schemes could also be developed during a period of interim storage. If the stored wastes are in solid form, however, subsequent redissolution for the purposes of partitioning could prove to be either technically unfeasible or too costly.

It is argued by some that, apart from the development of partitioning which would reduce the time required for waste isolation, scientific and technological progress that will take place during a period of interim storage will not reduce significantly the long-term risk of permanent disposition in geologic formations. If this is true then the incentives for a period of retrievable storage are greatly reduced. Furthermore, it is argued that even if significant progress is made during the interim period, society as that point may be unable to find the resources to retrieve the

waste and store it permanently, if this is then regarded as desirable. The prospect of societal collapse is also invoked in this context. There is no reason to expect such social disintegration to wait until the permanent disposition of radioactive waste has been completed.

Others feel that the hubris of a decision made now to select and implement a final disposition method -- a decision based on the supposition that current knowledge is adequate and unlikely to be improved significantly in the future -- must be avoided. They argue that, despite the additional responsibility that is involved, future generations would prefer to be in a position to make waste management choices of their own, rather than to witness passively the irreversible consequences of a previous decision. This point of view is sometimes expanded to propose the viability of a "permanent" retrievable storage option. Because of the limited time for which a single storage facility can retain its retrievability property, 'permanent' retrievability can only be retained by continual renewal and replacement of the systems used to isolate the waste -- a burden that is justified, in the minds of the proponents, by the fact that in a sense all options continue to remain open in successive generations.

The trade-off between the essentially irretrievable option of permanent geologic disposition and 'permanent' retrievable storage centers on the question of where reliance should be placed: on our existing ability to predict the evolution of geologic history over the next million years or so; or on the ability of future generations to manage the waste safely? From a different perspective one might argue that in the case of permanent retrievable storage, primary reliance is placed on the present and continuing ability to predict

the evolution of human history over much shorter periods. In this case, because of the periodic renewal of storage facilities that would be necessary, the time scales for prediction are measured in hundreds rather than millions of years.

It would be misleading to imply that 'permanent' retrievable storage concepts have received anything approaching the attention that has been given to permanent geologic disposition. Nevertheless, a direct comparison such as this helps to crystallize issues that may otherwise have been obscured if the discussion had focused solely on the "mainstream technological options."

Permanent Disposition of HL Waste

Many persons with diverse backgrounds believe that the most important decision to be made in developing a radioactive waste management system is the choice of a permanent disposition method. It is easy to understand why. The waste must be isolated from man and the environment for as long as it will present a potential radiological hazard. Without reprocessing, the isolation period will be more than a million years; with reprocessing it will be about two hundred thousand years less; with reprocessing and effective partitioning it will be at least one thousand years.

Unfortunately, one characteristic of choosing a permanent disposal method is that we can never know whether we have chosen safely, since such a long period of time is likely to elapse before errors in judgment or mistakes in implementation are likely to show up. This feature of decision-making regarding permanent waste disposition appears more extraordinary than it really is, however. Most major social decisions are made under large uncertainty and they effect a separate distribution of benefits, costs and risks within a society geographically and/or economically, if not across long stretches of time.

Here, we are concerned with what may be done to minimize the risk that something actually will go wrong.

A technical consensus appears to have been reached to the effect that the best place to isolate HL waste is under the earth's surface. The major debate concerns which areas of the earth's surface and which underground geologic formations are the most suitable. Continental land masses, the ocean floor, and polar ice caps are proposed as suitable areas. Since these three areas together include most of the surface of the earth, we must be more specific.

On land, a number of different geologic formations are being considered. Rock salt has been a candidate for over two decades. HL waste disposal in salt formations continues to be the favored alternative within the U.S. government. Hard, insoluble crystalline rock formations such as granite and basalt are in some ways preferable to plastically flowing, water-soluble salt, but in other respects they are less desirable. The same applies to formations of shale or sandstone.

More than two-thirds of the earth's surface is covered by the oceans. Some areas of the ocean deep seabed are geologically and seismically stable, are remote, and are biologically relatively unproductive. These areas are, moreover, separated from man's immediate environment by huge volumes of a diluting medium. Thus, the deep seabed contains possible sites for HL waste repositories. The disposal concept is not ocean dumping, but rather controlled emplacement of solidified, packaged, HL waste in either the argillaceous sediment or the underlying basaltic bedrock. The engineering capability to perform the required ocean floor operations is quite highly developed. Therefore, seabed disposal appears technically feasible. However, more knowledge is needed concerning the physical, chemical and biological mechanisms by which radionuclides in HL waste could be released from the repository and transported through the seabed and into the marine environment.

HL waste storage or disposal in or under the Antarctic ice sheet is an alternative that is currently not considered as attractive as deep continental or seabed disposal. Most of the schemes envisioned would allow the waste to melt its way through the icesheet, eventually coming to rest either at the ice-rock

interface or within the bedrock itself. Other concepts include the construction of an interim surface storage facility which, after decommissioning, would become covered with snow, and subsequently sink through the ice towards the bedrock.

The previous discussion has focused on the technological implications of the decision sequences involved in the implementation of various commercial HL waste management strategies. Some of the more important risks, costs and benefits arising from these decisions have been identified. An in-depth comparison, based on detailed and comprehensive studies, will be necessary to provide the foundation for choosing which particular strategy or strategies should be implemented.

Military HL Waste

This section discusses the military HL waste situation, and various ways in which it might be handled in the future. First, we discuss what may be done with the waste that has already accumulated. Then we consider the alternatives available for managing military HL waste generated in the future. The majority of the future waste will come from the continuing plutonium production program. The division is somewhat artificial, since management policy for waste in prospect is heavily influenced by previous practices. Nevertheless, by structuring the discussion this way, it is easier to focus on the important waste management issues. Figure 3.2 (on page 3-4) shows diagrammatically the management strategies currently applicable for military HL waste.

Existing Waste Treatment

In chapter 2, the quantities of existing military HL waste were briefly outlined. This information will now be augmented.

By the early 1980s, it is estimated that approximately 65 million gallons of HL waste will exist in solid form. An additional 9 million gallons will be "in process" as liquid that is being allowed to decay before solidification and liquid that cannot be solidified with present technology. At the present time, 72 percent of the military HL waste is stored at Hanford, 25 percent at Savannah River, and 3 percent at Idaho Falls. These ratios will not change appreciably by the early 1980s.

At Savannah River and Hanford, with the exception of the HL waste produced in the very early reprocessing plants that have long since been shut down, all HL waste is originally generated in acid form. Acid liquid HL waste must be stored in stainless steel tanks. In the immediate post-World War II years stainless steel was expensive and not easy to obtain. The decision was therefore made to neutralize the wastes. This increases the waste volume by about 60 percent and causes some of the more radioactive isotopes to precipitate out in a sludge. Nevertheless, neutralized waste can be stored in carbon steel tanks. These were (and still are) cheaper than stainless steel tanks, and were therefore used for storing the sludge and liquid after generation. The lifetime of carbon steel tanks was shorter than expected and leaks occurred.

One possible way to deal with the leaks would have been to reduce the working lifetime of the tanks. This could be done by building new ones and periodically transferring waste from one tank to another. An alternative procedure would be to solidify the waste.

The leaks would be stopped. Furthermore, since solidification reduces volume, extra storage space would be created in existing tanks. The latter alternative was cheaper, and it was selected.

Solidification of neutralized liquid HL waste is achieved by evaporating it down to a damp salt cake. Evaporation does not solidify all of the liquid, however, and there is always a quantity of residual liquor remaining. (Before solidifying the Hanford waste it is necessary to partition most of the Sr-90 and Cs-137. These isotopes are encapsulated and currently stored in water basins.) The solidification program will not reach a steady state until the early 1980s, by which time there will be approximately 450,000 tons of residual solids in the tanks.

What should be done with these solids? Should they remain where they are or should they be removed?

One possible course of action is to leave them where they are without further treatment. It is practically certain that such a plan would be deemed unacceptable. Salt cake is extremely soluble, the carbon steel tanks are corroding, and the arrangement would provide reliable containment for no more than a few decades. Another alternative is to leave the solids in the tanks and treat them further. The salt cake might be converted into a form less susceptible to leaching. Then the tanks might be covered with asphalt or concrete to make them more inaccessible to water and living organisms.

If the solids are to be removed from the tanks, the problem of extraction must be faced. Two methods are currently being considered. Neither seems very attractive. High-pressure water jets might be used to sluice out the partially dissolved solids. Such

a procedure would not be suitable for the many tanks (particularly at Hanford) that are cracked because dissolution of the salt would reopen the previously blocked cracks and cause still more leakage. Alternatively, the solid salt cake might be dug out of the tanks -- a risky procedure made more difficult because access to the tanks is limited to a few narrow vent pipes. Furthermore, the excavation work would increase the risk of airborne radioactivity.

After it is removed, what should be done with the salt cake? It will probably require further treatment to produce a solid form that is more suitable for permanent disposition. The technology required for this step is not yet developed. It is not clear whether there is a form that fulfills the dual requirements of long-term stability and the ability to be produced from salt cake.

Finally, the costs of treatment and removal of existing military HL waste from tanks at Hanford and Savannah River must be mentioned. Cost estimates vary over a wide range from \$2 to \$20 billion dollars just to prepare the existing military HL waste inventory at Hanford and Savannah River for permanent disposition. Two conclusions seem appropriate: (1) The cost of managing military HL Waste is likely to be greater than the cost of commercial waste management for quite some time to come. (2) In radioactive waste management, the longer term consequences of decisions made only on the basis of short-term considerations can be enormous. It should also be remembered that "longer term" here means about 50 years -- a very small fraction of the toxic lifetime of the waste.

The situation at Idaho Falls with regard to existing solid HL waste is significantly different from Hanford and Savannah River. At this site, the acid waste has not been neutralized. Instead, it

has been stored temporarily in stainless steel tanks. Since the opening of the waste calcination facility in 1963, it has been processed to form a dry granular solid called waste calcine. The calcined waste is stored in stainless steel bins partially underground. The lifetime of these bins is estimated to be several hundred years.

Calcined waste, however, is relatively leachable. Bin storage cannot therefore be relied upon to provide adequate isolation for the toxic lifetime of the waste. Thus the question of when to begin removal will have to be settled. Unlike the situation at Hanford and Savannah River, the removal of solid wastes from storage bins will not be a very difficult technical operation. In view of the technical similarity between the waste produced at Idaho Falls and that from the commercial power reactor program, (they are both retained in acid form, and then calcined), the waste management decisions made for each should presumably be consistent. For example, it would not seem consistent to decide upon an extended period of storage for calcined waste in bins at Idaho Falls and also decide that retrievable engineered storage is not suitable for commercial HL waste.

Management of Future Wastes: Short-Term

Major modifications to existing management practices for HL waste at Idaho Falls do not appear necessary in the immediate future. The important decisions yet to be taken concern the post-calcination steps and apply equally to existing and future waste.

This is not the case at Hanford and Savannah River. The root of the present problem, and its magnitude is considerable, seems to have been the initial decision to neutralize the acid waste. This practice continues. The issue is: should future acid HL waste be neutralized? At this stage, it is helpful to briefly compare a neutralized waste/salt cake system with an acid waste/calcline system.

As discussed previously, the initial decision to neutralize was based on the availability and cost of carbon steel compared to stainless steel. The former is still cheaper than the latter, but it should also be remembered that neutralization results in a significant increase in volume so that the tankage required for acid storage is less than for storage as a neutralized solution. The lifetime of stainless steel tanks is longer than that of carbon steel tanks for waste storage purposes.

Solidification technology is different for the two systems. Calcined waste, although not suitable for long-term storage because of its leachability, is a satisfactory base from which to produce glasses and other more suitable forms. Calcination of acid waste has taken place routinely since 1963. On the other hand, it is not possible to calcine neutralized wastes with present technology, and the evaporation/crystallization method used to solidify waste at Savannah River and Hanford is not entirely satisfactory. In addition, salt cake is more soluble than calcine, and is clearly not suitable for long-term storage. A method for converting it into a less leachable form such as glass has not yet been demonstrated on a commercial scale, and it will be a difficult problem to solve.

The volume of salt cake per unit of spent fuel reprocessed is significantly greater than the corresponding volume of calcine produced by an identical amount of spent fuel. Finally, calcined waste in bins at Idaho is much more retrievable than salt cake, especially the material in the flawed tanks at Hanford.

With this comparison in mind, we may consider the question of whether or not to continue to neutralize future HL waste at Hanford and Savannah River. At Hanford, the military production of plutonium is gradually being phased out. Of the nine production reactors that have operated at one time or another over the past thirty years, only one is still functioning, and that one will probably be shut down within a few years. Therefore, in view of the relatively small quantity of HL waste that is still to be generated at Hanford, a switch to an acid waste management system at this stage may be uneconomical. The Savannah River plant is now the major plutonium production facility in the U.S., and will continue to generate HL waste in relatively large quantities for as long as plutonium is required for nuclear weapons. In this case, it may be preferable to convert to an acid-calcine system. Nevertheless, a recent assessment, based upon economic estimates to 2000, indicates that it will be cheaper to continue with an improved neutralization-salt cake system than it would be to convert to an acid-calcine system.

Permanent Disposition: Existing and Future Waste

It is sometimes suggested, or charged by critics of government management, that existing military HL waste, in salt cake form, can be left in existing tanks, more or less permanently. Enough has been said previously to indicate that such a solution is clearly unsafe.

Regrettably, further procrastination is possible and perhaps likely in view of the costs involved.

After HL solid waste has been removed from the tanks and converted into a different form, it is necessary to decide on a site for final disposition and then to package and transport the waste to the site chosen. (Retrievable interim storage is also a possibility, but it would be an additional costly stage in an already very costly program, and, depending on the performance of the existing temporary storage facilities over the next few decades, it might also be unnecessary.) The location could be either on or off the tank storage site. On-site disposition seems most unlikely. Earlier AEC efforts to establish the feasibility of on-site geologic disposal of the solidified HL waste at both Hanford and Savannah River have been suspended indefinitely. The alternative off-site permanent disposition methods for solidified military HL waste are similar to those for solidified commercial waste. However, alternatives that are international in scope, specifically deep seabed and ice sheet disposal, may not be available for military waste disposal if other governments raise political and legal objections.

Demonstration of Permanent HL Waste Repository

The U.S. government presently plans to have begun a "demonstration" of a permanent HL waste repository by 1985. Based on the results of site selection and R & D programs that are already underway, the demonstration is believed to be necessary as one of a series of actions to "close" the nuclear fuel cycle (i.e. to begin commercial reprocessing and plutonium recycling in LWRs). 1985 is the target date for the initial waste repository demonstration to begin because that is the earliest date that solidified HL waste from a

commercial reprocessing plant will be received for permanent disposition. The logic of the schedule -- reprocessing plant; interim storage of liquid; solidification; transportation; disposal -- assumes that all stages are developed in a timely and orderly manner.

The demonstration will begin with the establishment of a pilot facility which is ready to receive waste in 1985, to be followed by expansion, and then, if nothing unforeseen has occurred and the demonstration has been successful, conversion into a full-scale federal repository after about ten years, or about 1995. The change from an expanded pilot plant to a full-scale federal repository will be characterized by the conversion of retrievable storage facilities into irretrievable disposal. Six sites for repositories will be established on a staggered basis, with the first two in salt and the next four in formations other than salt.

In 1985 there will be no absolute necessity for a federal repository for the ultimate disposal of HL waste. The absence of such a repository would not result in a technical inability to generate nuclear electric power. Moreover, such a repository is not the only way to prevent harmful health or environmental effects arising from the HL waste. So, we must look elsewhere for the reasons behind the existing schedule for the demonstration and creation of a permanent waste repository.

What are the technical benefits from the operation of a pilot-scale permanent repository for about ten years? Experience will be gained: in the handling of packaged solid waste; in the construction and operation of surface and underground facilities for receiving waste; in the emplacement of wastes in the geologic formation; and in the measurement of the physical effects of waste emplacement. It will, of course, be impossible to "demonstrate" with

any reasonable assurance of validity, the capability of the repository to contain HL waste over the period for which it constitutes a potential radiological hazard. What can be demonstrated is the ability to receive and emplace solid waste in the repository.

What are the possible non-technical benefits from the demonstration? It seems generally acknowledged that one of the major obstacles to public acceptance of nuclear power is concern that there is no safe solution to the radioactive waste problem. It is believed by many that this concern is derived, at least in part, from the absence of a demonstrated permanent waste repository. It seems reasonable to conclude that one of the most important purposes intended by the waste repository demonstration "on a timely basis" (i.e., by 1985) is to increase public confidence.

But what worries the public about the disposal of radioactive waste? It is the concern that, in pursuit of our objectives of providing ourselves with energy and security, we might also be responsible for harm inflicted on one or more generations far into the future by failing to provide adequate isolation of this radiologically hazardous material.

Assuming the demonstration is successful within its limitations, what will it help to achieve in public confidence? It is possible that a demonstration will satisfy the public that the task of radioactive waste management can be dealt with safely. But if this occurs, the demonstration will have created an "illusion of certainty" (to quote Kenneth Boulding's phrase). Even those who have great confidence in the ability of our society to dispose of radioactive waste in a safe manner would not claim that the operation of a waste repository for a few years will, in itself, provide substantial evidence to support a conclusion that the waste is very unlikely

to harm man or the environment thousands of years in the future. Should we proceed on the basis of such an illusion of certainty in the public mind, even if the illusion is not shared by those in authority?

Another possibility is that the general public becomes more sophisticated in its ability to make judgments on the basis of technical and probabilistic information, and the predominant view will be that the risks of radioactive waste disposal are acceptable. If such a development actually takes place, the public will not regard the demonstration as being very significant as an input into a long-term decision-making process. A third possibility is that there will be a public reaction against what is seen as an attempt to manipulate opinion with the demonstration. In this event, the obstacle which the radioactive waste problem poses to public acceptance of nuclear power will become even greater.

It may be concluded from this discussion that it would be unwise to rely heavily on the successful demonstration of a pilot permanent waste repository to obtain public acceptance of the waste management program. Therefore, all the uncertainties associated with the various nuclear waste management strategies discussed previously in this chapter should be fully aired. Indeed, the tendency of many of those involved in the resolution of nuclear issues to interpret current public sensitivity to waste management issues as public pressure for quick resolution may be misguided. An alternative argument is that the current ill-defined sensitivity will eventually articulate itself into a clearly stated desire for slower but surer resolution.

Commercial TRU Waste

Under existing ERDA standards and proposed NRC regulations, TRU waste is defined as low-level waste which is presumed to contain more than ten nanocuries of long-lived transuranic radioactivity per gram. This definitional limit is currently being studied and may be revised upward.

Low-level, transuranic contaminated waste (TRU waste) will require more careful management than other kinds of low-level waste because of the very long time for which it will remain a radiological hazard. Indeed, assuming that reprocessing and recycling are introduced using existing process methods, more than half of the plutonium released in nuclear fuel cycle wastes will be contained in low-level waste streams. However, although TRU waste contains at least as much plutonium as HL waste, the plutonium concentration is very much lower. Nevertheless, quantities of long-lived radionuclides rather than their concentrations should probably be given more weight in basic policy decisions.

TRU waste streams of three types--non-combustible solid, combustible solid and liquid--are generated by three stages of the commercial fuel cycle--reprocessing, the conversion of liquid plutonium nitrate to solid plutonium oxide and mixed oxide fuel fabrication. Measured by the amount of plutonium contained in TRU waste per unit of electric power produced, TRU waste is created in these three stages at roughly the same rate. In similar units, each type of TRU waste--combustible and non-combustible solids and liquid--is produced at approximately the same rate. These two facts imply that all TRU waste streams from all TRU waste producing stages of the fuel cycle should receive equal attention.

With this brief introduction in mind, we will discuss the major TRU waste management decisions. As with HL waste management, all decisions are interdependent.

The management of TRU waste can be affected by operational changes at the points of generation. As in the case of HL waste management, this concept is one of prevention rather than correction. For instance, the efficiencies of plutonium recovery at the reprocessing plant* and plutonium utilization at the mixed oxide fuel fabrication plant could both be improved, so that less plutonium is lost in the TRU waste streams. The argument used earlier for plutonium recovery from HL waste involving the law of diminishing returns applies here. It may be economic to remove part of the plutonium contained in some TRU waste and recycle it to reactors. But in order to obtain a significant reduction in the long-term environmental risks from these wastes, it will be necessary to achieve a higher recovery efficiency. The cost of these operations will not match the value of the extra fuel obtained as a result. It therefore seems likely that the reprocessor and fabricator would require some form of encouragement--a government subsidy as a carrot or regulatory standard as a stick--if these improvements are to be achieved. Similar considerations apply to the flowsheet modifications that could be made at reprocessing and mixed oxide fuel fabrication plants to make the physical form and chemical composition of the TRU wastes more suitable for subsequent waste management operations.

*For convenience, the nitrate-oxide conversion facility will now be considered as part of the reprocessing plant. In practice, the two functions, reprocessing and conversion, will essentially be combined into one process flowsheet.

The issue of improved plutonium recovery is related to the HL waste partitioning question. The ability of waste partitioning to reduce the long-term risk of HL waste management has already been discussed. Since the amounts of long-lived radionuclides in unpartitioned HL waste and untreated TRU waste are similar for each unit of electricity produced, it is argued that a decision taken to partition HL waste, if consistent, would have to be accompanied by a decision to remove enough of the transuranics (mostly plutonium) from the TRU waste to achieve a corresponding reduction in long-term risks.

Transuranic recovery from TRU waste would precede or follow a number of other treatment steps. For instance, sorting and shredding followed by incineration of combustible waste produces a residue (or ash) that can be processed for plutonium recovery. An incentive for incineration (or some other method of combustion) is the volume reduction that is achieved. Reduction factors varying between 20 and 50 are claimed for the different processes. Mechanical compaction can also be used to reduce the as-generated volume of both combustible and non-combustible solids.

In view of the great variation in TRU waste streams generated in reprocessing and mixed oxide fuel fabrication plants, it is not surprising that there are a great many different treatment technologies. Some of them are still at an early stage of development, probably because the commercial nuclear industry has not begun to generate TRU waste in significant quantities, and until recently TRU and non-TRU low-level wastes were not distinguished in management operations involving military and research and development waste. Others are equally applicable to TRU and non-TRU wastes, and certain

of these have been used routinely for some time. A substantial proportion of these generally applicable non-high-level waste treatment technologies have not yet been introduced into commercial waste management systems.

Nevertheless, all of these technologies are designed to achieve one or more of the following objectives: the creation of a waste form with good long-term storage properties; volume reduction; the reduction of short-term risks. In all cases, the importance of minimizing secondary waste stream production is clear, since each operation involving the handling of radioactive materials tends to disseminate the radionuclides in the feed stream among a number of different output streams.

The final two stages in TRU waste management--each of which bears directly on the long-term risk posed by this waste--are immobilization and final disposition. They must combine to prevent the migration of radionuclides from TRU waste to the biosphere. Again, in view of the wide variety of TRU waste forms, there will be a number of applicable immobilization technologies.

It is becoming increasingly likely that the long-term isolation criteria that will be applied to HL waste will also be applied to TRU waste. The logic behind this trend is based on the realization that the amounts of long-lived radioactivity in these two waste categories are comparable, although the concentrations are, of course, significantly different. Decisions concerning the permanent disposition of HL and TRU wastes will be closely related, and the options presented in the section on HL waste are applicable.

Military TRU Waste

Military TRU waste comes principally from two sources--plutonium separation from irradiated plutonium production reactor fuel and the fabrication of nuclear weapons. Information concerning the latter is classified. As has already been mentioned, until 1970 TRU waste under the jurisdiction of the old AEC (most of which had a military origin) was emplaced in shallow burial grounds with no provision for retrieval. Since then, TRU waste at ERDA (formerly AEC) burial sites has been stored retrievably above ground.

Taking the long-term perspective, particularly with regard to permanent disposition, it seems unjustifiable to manage the military and commercial TRU wastes so that the risks posed by one will be greater than those posed by the other. The waste must be managed consistently, regardless of origin. In the case of the weapons fabrication waste this may present security-related problems. But these difficulties can be solved administratively, and they should not obscure the fundamental waste management issue--the long-term nature of the risk.

Conclusions

From the preceding discussion of radioactive waste management strategies, the following conclusions are drawn:

1. The decision whether or not to reprocess commercial power reactor fuel has fundamental importance for the future development of nuclear fission as a source of energy. Nuclear fission will be a long-term energy option only with reprocessing and successful breeder reactor development. Either the uranium/plutonium, or the thorium/uranium-233 fuel cycle, or a combination of both, are possible as long-term fission energy options, but the uranium/plutonium

fuel cycle is the more likely to mature first. With reprocessing and plutonium recycling in existing commercial LWRs only, the short lifetime of the fission energy option based on the uranium/plutonium fuel cycle is only marginally extended.

The reprocessing decision may be delayed and spent fuel discharged from LWRs may be stored pending the outcome of breeder reactor development and demonstration efforts now underway. If, however, reprocessing is ruled out permanently, then the costly breeder reactor development program should be promptly stopped and the funds and manpower currently devoted to it should be allocated to development of other long-term energy options instead of nuclear fission. From another perspective, the continued top priority assigned to plutonium breeder reactor development and the expenditure of resources in support of that priority in the U.S. (and every other country with a major nuclear power program) imply that the decision in favor of reprocessing has already been made in principle, and that the remaining issues are when and on what conditions reprocessing should begin.

2. Radioactive waste management is an important, though not in itself decisive, issue in the reprocessing decision. If commercial spent fuel is not reprocessed, over the long-term it will be a major waste management problem. Some form of reprocessing may eventually be necessary as a waste treatment measure, if not to recover uranium and plutonium for use as fuel. If commercial spent fuel is reprocessed for the purposes of fuel recycling, then HL and TRU waste streams which emerge principally during reprocessing and uranium/plutonium mixed oxide fuel fabrication will be interrelated long-term waste management problems.

3. The decision whether or not to reprocess military fuel was made at the outset of the U.S. nuclear weapons program in order to obtain plutonium for use in weapons. From past military plutonium production, the legacy of liquid and solid accumulations of HL waste in temporary tanks constitutes a multi-billion dollar treatment problem before the waste can be safely placed in a permanent repository.

4. Radioactive waste management operations are interdependent. The risks and costs of permanent disposition methods affect and are affected by waste partitioning and solidification or other treatment methods. In view of the long-term risks, essentially all HL and TRU waste, regardless of its commercial or military origin, should be eventually destined for one set of government-managed radioactive waste repositories.

5. Decisions regarding every phase of radioactive waste management must be made under uncertainty. Research and development can narrow technological uncertainty. Short-term demonstrations of permanent waste repositories can show that radioactive waste can be safely emplaced in geologic formations, but little more.

6. Radioactive waste management requires comprehensive strategic planning. A key issue in such planning is the distribution of risks and costs through time. In radioactive waste management, quality of thought is more important than timeliness in decisions because the current costs of delay are likely to be much less than the future costs of error. This reasoning runs counter to the strong pressure, which currently exists, for an early "solution" to the radioactive waste problem.

7. From a technological standpoint, radioactive waste operations require a fully integrated management framework. The management framework should be vertically integrated so as to include all operations from temporary waste storage, through treatment and transport to permanent disposition. The framework should be horizontally integrated to include post-fission HL and TRU wastes of commercial and military origin.

* * *

Radioactive waste management will be a continuing challenge for government throughout the nuclear age, and perhaps for many centuries beyond.

Chapter 4

EXISTING POLICY, LAW AND ORGANIZATION

Having considered the character of radioactive waste in chapter 2 and the range of strategic decisions involved in waste management in chapter 3, we are now in a position to analyze in some detail the existing situation in the U.S. regarding radioactive waste management and regulation. First, the policy goals are briefly discussed. Next, the organizational structure for management, regulation, and research and development related to radioactive waste is analyzed. Finally, the existing situation regarding implementation of radioactive waste policy is described.

Goals

Present statements of the basic policy goals of radioactive waste management vary somewhat according to the federal government agency concerned. The statements of EPA and ERDA to date have focused mainly on technological safety objectives. EPA's position is that

Waste management means containment of radioactive materials until they have decayed to innocuous levels. The objectives that EPA has are to minimize exposure to present and future populations and to avoid dilution into the biosphere.¹

ERDA's is similar: ". . . the effective management of nuclear wastes in a manner which effectively protects man and his environment . . ."² With respect to commercial HL waste in particular, "[ERDA's] objective is to provide multiple terminal storage sites on time to receive solidified waste without inhibiting the power industry."³ ERDA is, of course, also committed to continue the nu-

clear weapons production and naval nuclear propulsion programs. ERDA has acknowledged the importance of broad public participation in the selection of technological options, so that the options ultimately chosen will gain broad public acceptance.⁴

NRC has set forth the broad goals of its regulatory efforts in these terms:

1. Isolation of radioactive wastes from man and his environment for sufficient periods (in some cases hundreds or thousands of years) to assure public health and safety and preservation of environmental values.
2. Reduction to as low as reasonably achievable:
 - a) Risk to the public health both from chronic exposure associated with waste management operations and possible accidental releases of radioactive materials from waste storage, processing, handling or disposal.
 - b) Long-term social commitments (land-use withdrawal, resource commitment, surveillance requirements, committed site proliferation, etc.)⁵

In contrast to ERDA, NRC has expressed interest in attaining certain social, economic, and environmental as well as technical goals. The NRC staff has organized a task force to assess policy issues and to recommend for the Commission's consideration a statement of generally acceptable goals and objectives for the management of nuclear wastes. The draft task force report reflects concern with matters like the institutional arrangements required for waste management, economic impacts, the foreclosure of future options, time frames for action, distribution of hazards and benefits, the uncertainties which will plague decisionmaking, and public involvement in waste management decisions.⁶

Organizational Overview

To carry out waste management goals a set of institutional arrangements is required. The overall organization must include capacities for three generic functions: waste management itself, regulation of waste management to assure safety, and research and development to improve both management and regulation. "Waste management" is the actual performance of physical and administrative tasks required for the proper short and long-term handling of radioactive materials. These activities include temporary storage, treatment, packaging, transportation, and retrievable storage or permanent disposition. Retrievable storage and permanent disposition may be termed "long-term" activities, while all others are "short-term," regardless of when they occur. Current management responsibilities can be described by considering in turn each of the four categories of post-fission waste, based on type and origin within the scope of this report: (1) commercial HL waste; (2) military HL waste; (3) commercial TRU waste; and (4) military TRU waste. Responsibility for management is variously divided between ERDA and private industry depending on the type and origin of post-fission wastes. The regulatory function includes basically three types of activities: setting general criteria and specific standards, licensing or approving various managerial activities (e.g., siting, construction, and operation of facilities), and monitoring and enforcement related to ongoing operations. Again depending on the type and origin of post-fission waste, primary responsibility for regulation is divided among NRC, ERDA and certain states. Superimposed upon the primary regulatory responsibilities of several "non-nuclear" agencies, which

derive their jurisdiction from legislation on transportation or the environment. Contrasted with the complexity of institutions involved in management and regulation, a single agency, ERDA, sponsors or conducts the great bulk of radioactive waste research and technology development.

Management

The Atomic Energy Act of 1954⁷ and the Energy Reorganization Act of 1974⁸ split managerial responsibilities between ERDA and licensees of NRC or Agreement States.⁹ ERDA personnel, however, do not actually operate ERDA's waste management facilities: this work is done almost entirely by ERDA contractors subject to ERDA management policies. Thus, when this report refers to ERDA or federal "management," it implies such a two-tiered managerial arrangement.

Commercial HL waste is to be managed by licensees until it is delivered to ERDA facilities for final disposition. Under current regulations licensees must solidify liquid HL waste no later than 5 years after its generation and must transfer it to an ERDA repository no later than 5 years after its solidification.¹⁰ Thus short-term responsibilities (temporary storage, treatment, packaging, transportation) fall upon private industry and long-term responsibilities, (retrievable storage or permanent disposition) fall upon the federal government. Responsibility for management of military HL waste resulting from weapons production and naval nuclear propulsion programs is comprehensively vested in the federal government. DOD is a relatively minor manager of military

waste, since it must handle spent fuel elements from naval reactors for only limited periods of time, until they are transferred to ERDA. DOD does not manage HL waste from weapons production, since ERDA itself produces plutonium for weapons; it is during plutonium recovery that weapons HL waste is generated.¹¹

The present law and NRC regulations allow private industry licensees to have short- and long-term management responsibilities for commercial TRU waste. Regulations proposed by the AEC and inherited as proposals by NRC would alter this situation for the long-term, however. The proposed regulations could prohibit burial of any transuranic waste and require licensees to transfer all transuranic waste to federal (i.e., ERDA) facilities within five years of generation.¹² Resolution of certain technical and economic problems with the proposed regulation plus the preparation of an Environmental Impact Statement on it are necessary before promulgation. All but one of the six commercial low-level waste burial sites now in operation have suspended TRU waste burial.¹³

Most military TRU waste is managed within the federal government by ERDA in the long-term and by ERDA and DOD in the short-term. Again, DOD manages relatively small amounts of TRU waste from weapons component assembly and naval propulsion programs, which it transfers to ERDA as soon as possible within its own operational and national security commitments. It should also be noted that several commercial operators inherited some buried military TRU waste when they took over sites which had previously been run by the AEC. At least one commercially operated burial site (at Hanford) continues to receive military TRU waste from nuclear navy operations.¹⁴

Regulation

The body of radioactive waste regulation is still in the early stages of development. This should be borne in mind throughout the following discussion.

Criteria and Standards

Basically, authority to promulgate radiation safety criteria and standards applicable to radioactive material is vested in the federal government.¹⁵ NRC and ERDA have authority, derived from the Atomic Energy Act of 1954 and the Energy Reorganization Act of 1974, to establish license criteria and standards for protection against radiation.¹⁶ EPA, however, also has a claim in this area. When it was created in 1970, it received, among other powers, the authority of the Federal Radiation Council, which was then abolished, to

. . . advise the President with respect to radiation matters, directly or indirectly affecting health, including guidance for all Federal agencies in the formulation of radiation standards and in the establishment and execution of programs of cooperation with States.¹⁷

The 1970 Reorganization Plan also transferred from AEC to EPA the responsibility for

" . . . establishing generally applicable environmental standards for the protection of the general environment from radioactive material. As used herein, standards mean limits on radiation exposures or levels, or concentrations or quantities of radioactive material, in the general environment outside the boundaries of locations under the control of persons possessing or using radioactive material.¹⁸ (emphasis added)

EPA has relied to date upon this latter language, which excludes from EPA radiation standard-setting both ERDA and licensee activities

which are located geographically within the possessor/user's facility. (Thus EPA has jurisdiction to set exposure standards for transport of wastes.) Some EPA statements, however, indicate an attempt to expand its standard-setting authority to reach within the boundaries of NRC-licensed or ERDA facilities by reviewing NRC's and ERDA's own standards for protection against radiation under the authority of its "guidance" mandate.¹⁹ This would create regulatory redundancy and perhaps conflict. So far EPA has not tried to alter the nuclear agencies' standards for operations.

Licensing/approval activities are the central function of post-fission waste regulation, and they present the most complicated aspect of the present situation. While NRC and ERDA have general licensing/approval duties within their respective areas of jurisdiction, several other institutions, within and outside of the federal government, have claims of varying strength for additional, occasionally overlapping, authority to license as well. Before discussing these additional institutions, we will outline current allocations of regulatory authority between NRC and ERDA for the various regulatory activities aside from standard-setting, and identify some of the uncertainties that exist within each category.

Siting HL and TRU Waste Facilities

Siting requirements adopted to date concern mainly land ownership. ERDA's practice is to purchase, rather than to lease, land for its use; thus ERDA waste management facilities are and will be located on federally-owned land. "[D]isposal of high-level radioactive fission product waste material will not be permitted

on any land other than that owned and controlled by the Federal Government."²⁰ Current NRC regulations, on the other hand, require applicants for low-level waste burial licenses to provide²¹ an environmental analysis of the proposed site and allow burial²² only on land which is owned by the federal or a state government. Reprocessing plants and temporary storage facilities for HL waste²³ may be located on privately-owned property. Whereas TRU waste disposal can now take place on State or Federal land, proposed regulations would limit it to property owned by the U.S. government.²⁴ Further siting requirements are being developed by the Office of Nuclear Material Safety and Safeguards within NRC. The role of other federal and state agencies in siting is discussed further below.

Facilities Construction and Operation: HL Waste

NRC has sole authority to license commercial HL waste management facilities and operations. Moreover, section 202(3) of the Energy Reorganization Act of 1974 subjects any ERDA facility handling commercially-generated HL waste to NRC licensing. It would even appear that ERDA research and development facilities using²⁵ commercially generated HL waste are subject to NRC licensing. ERDA is not planning to use commercial HL waste in its pilot plants for demonstration of a permanent waste repository; ERDA may thus²⁶ avoid NRC licensing. ERDA is now grappling with the problem of obtaining a suitable quantity and composition of waste similar to commercial HL waste for use in its demonstration projects.

ERDA contractors are responsible for day-to-day management of military HL waste, as noted above. These are supervised, in

a management sense, and regulated for safety assurance, by ERDA through the terms of its contracts. ERDA manual chapters on waste management (which give very general guidance),²⁷ standards for protection against radiation,²⁸ reporting of occurrences,²⁹ etc., are incorporated by reference into the contract terms. The ERDA approval of contractor operations is obviously not as publicly open as NRC approval of its licenses. But this type of ERDA self-regulation is specifically authorized by the Atomic Energy Act of 1954.³⁰ The approach may be justifiable on national security grounds in part. At any rate, for the short-term, ERDA exercises regulatory control over its own military HL waste.

For the long-term, section 202(4) of the Energy Reorganization Act gives NRC licensing authority over the following ERDA facilities:

. . . . Retrievable surface storage facilities and other facilities authorized for the express purpose of subsequent long-term storage of high-level radioactive waste generated by the Administration, which are not used for, or are part of, research and development activities.³¹

Thus NRC clearly must license the long-term disposition of both commercial and military HL waste. However, the statutory language raises a number of definitional issues such as the meanings of "long-term," "subsequent," and "high-level radioactive wastes." The meaning of this section has been raised in a petition to NRC challenging ERDA's planned construction of several new waste storage tanks without NRC licensing.³² Resolution of this question is important with regard to NRC's regulatory authority over a large segment of the existing waste inventory. Two major points

should be stressed in explaining the division of authority created by this provision of existing law.

First, it has been generally accepted that (AEC) military HL waste that existed at the time the Energy Reorganization Act was enacted, located at such federal reservations as Hanford, Savannah River, and Idaho Falls, is not subject to NRC licensing. This is notable partly because some of the waste in question has been stored at these ERDA facilities since the 1940s. Some have asserted that anything longer than 30 years constitutes long-term storage.³³ More significantly, ERDA has for some time been solidifying liquid HL waste in place within storage tanks to prevent further leakage. The result of this action, as discussed in chapter 3, is that ultimate removal of this solidified HL waste for transfer to NRC-regulated long-term storage facilities may prove prohibitively expensive.³⁴ ERDA may thus retain "long-term" regulatory authority over military HL waste as long as it remains solidified in tanks which existed prior to the passage of the Energy Reorganization Act. ERDA cannot, however, avoid NRC regulation of additional long-term storage facilities. If ERDA is faced with leaks in any new tanks for temporary storage, and it adopts a solidification strategy again as an emergency management measure, NRC may be able to step in as a licensor. But at such a late stage NRC will have been excluded from the siting and construction decisions, which are perhaps the most crucial steps in the licensing process.

Nevertheless, NRC's basic licensing authority over the permanent disposition of military HL waste, which obviously includes the promulgation of safety criteria for acceptance of waste at a

permanent repository, could give it substantial indirect control over at least some aspects of short-term ERDA management (e.g., form of waste, type of packaging). This would not, however, enable NRC to exercise short-term monitoring and enforcement with regard to ERDA wastes, nor to establish a schedule for ERDA waste treatment in preparation for transfer to a permanent waste repository.

The second major point is that in a similar way the exclusion of ERDA research and development facilities from NRC licensing may deny NRC meaningful safety regulation of several permanent waste storage facilities. Having sited, constructed, and demonstrated a pilot plant without an NRC license, ERDA may then declare it capable of operating as a permanent repository. NRC will have been shut out again from the original siting and construction decisions.

Facilities Construction and Operation: TRU Waste

The 1959 Amendments to the Atomic Energy Act of 1954 made provision for states to regulate commercial low-level waste operations within their boundaries under the Agreement States program.³⁵ Pursuant to these provisions, NRC essentially delegates this part of its regulatory power to states desiring this authority and conforming to the Commission's standards. But it retains the authority to suspend or revoke an Agreement if the public health or safety is threatened.³⁶ The suspension power has never been exercised thus far. Pursuant to the Agreement States program, certain states wholly or partially regulate all but one of the six currently operating commercial burial facilities at Barnwell, S.C.; Beatty,

Nev.; Hanford, Wa.; Moorehead, Ky.; and West Valley, N.Y. (The Sheffield, Ill. site is under exclusive federal jurisdiction.)³⁷

Proposed regulations prohibiting shallow land burial of TRU waste and shifting long-term management of such waste from private operators to ERDA would take this aspect of regulatory authority out of the Agreement States and place it once more in the federal government. It would be logical for NRC to have this role, in light of its parallel long-term regulatory responsibilities for commercial HL waste. However, existing law expressly provides for NRC licensing of long-term storage of HL waste only.³⁸ Apparently, NRC is tending toward simplifying the defined categories of radioactive waste into high- and low-level only.³⁹ If necessary, NRC might indirectly exercise control over long-term TRU waste repositories by setting design criteria for sites and receiving facilities in requirements for transport by NRC licensees of TRU waste to permanent repositories. A more straightforward solution to this ERDA-NRC jurisdictional problem would seem to require legislation.

NRC is currently rethinking the radioactive waste aspects of its Agreement States program. Discussion between NRC staff members and State government radiation control officials has begun.⁴⁰ Such reconsideration is taking place in an environment of waning state financial capacity, and increasing controversy about low-level burial sites. Apparently, many states would willingly rid themselves of the expense and responsibility of this phase of radioactive waste regulation.

ERDA has sole regulatory authority over military TRU waste. DOD regulates the short-term management of TRU waste generated by weapons component assembly or naval nuclear propulsion programs at

DOD facilities themselves, but this waste is transferred eventually to ERDA.

No definition of "high level radioactive waste" is supplied by the Energy Reorganization Act itself. However, at the time the Act was passed, the term would already not have included TRU.⁴¹ Nonetheless, current practice and proposed regulations view trans-uranic waste with considerable concern since, as discussed in chapter 3, quantities of plutonium contained in low-level and high-level wastes generated by commercial plutonium recycle will be roughly equal.⁴² Yet the existing U.S. regulatory structure does not provide firm assurance of NRC regulation of either commercial or military TRU waste.

NRC efforts now underway in the area of waste regulation include:

- 1) development of a regulatory waste management program;
- 2) establishment of a confirmatory research program to support regulatory and licensing activities in waste management;
- 3) classification of the types of nuclear wastes;
- 4) development of specifications for the types of solids which are acceptable forms for HL waste;
- 5) review of requirements for the disposal of low-level waste at commercial burial grounds; and
- 6) coordination of activities with state and local governments and other federal agencies.⁴³

Transportation

Charged by a series of legislative enactments culminating in 1975, DOT shares responsibility with the nuclear agencies for insur-

ing safe transport of hazardous radioactive materials in commerce. Recognizing their common jurisdiction, DOT and AEC in 1973 entered into a Memorandum of Understanding allocating regulatory duties in this area.⁴⁵ The Memorandum recognizes DOT's general authority to develop safety standards for packaging by shippers and handling by carriers, but allows AEC to develop criteria for packages of Type B, large quantity, and fissile materials. Each agency further pledges to enforce the other's standards when monitoring parties under its jurisdiction and to exchange information prior to issuing new regulations in this area. The Memorandum was signed before the AEC split into NRC and ERDA. It is now applicable to both, since the AEC specifically imposed the same regulatory obligations for transport upon both its licensees and its license-exempt contractors. ERDA has acknowledged its obligations by carrying forward the relevant AEC manual chapter into its own body of manual chapters, which is by standard practice incorporated by reference into all ERDA shipper contracts.⁴⁶ NRC likewise has adopted without significant variation that part of previous AEC regulations pertaining to the packaging of radioactive material for transport.⁴⁷ Both nuclear agencies also require shippers to follow a registration and approval procedure that parallels DOT regulations for the shipment of non-radioactive hazardous materials.⁴⁸ As was indicated above, all waste shipments outside ERDA or NRC facilities must also meet EPA's generally applicable standards for protection of the environment against radiation.⁴⁹

There is one exception to the federally dominated scheme of regulation. In the case of transportation of wastes containing less than critical mass quantities of special nuclear materials within

Agreement States, neither DOT nor NRC have jurisdiction. State laws and regulations apply. But all Agreement States require packaging to comply with DOT standards.⁵⁰

Current federal transportation and packaging regulations, in effect since 1968, are virtually identical to the regulations adopted by the IAEA in 1961. The IAEA, however, revised its regulations in 1973. ERDA and NRC are now considering revisions in response to these changes by the international organization. A number of recent radioactive waste transport incidents have sparked controversy. Also, most of the state nuclear power initiatives that have been proposed include provisions on transportation. In response, NRC has committed itself to a program of emergency response planning, environmental impact assessment, and risk analysis.⁵¹

Monitoring and Enforcement

The Atomic Energy Act of 1954 grants both agencies ample authority for monitoring and enforcement.⁵² Monitoring consists mainly of screening required reports, auditing managers' inventories, and inspecting sites. Enforcement involves the punishment of violators and ordering remedial safety actions, particularly during emergencies. NRC has general regulations governing these activities,⁵³ and ERDA conditions its contracts on adherence to manual chapters with similarly general requirements.⁵⁴ If a contractor cannot be convinced to comply with manual chapter standards, ERDA may rescind the contract and, if necessary, confiscate the facility.

It is unclear, however, how ERDA manual chapters compare in legal weight with regulations such as those formulated by NRC and published in the Code of Federal Regulations. From ERDA's standpoint as a regulator the question is unimportant, since it can exert contractual pressures on its managers. But the issue may be important to an intervenor seeking a court order against ERDA requiring it to enforce its own standards.

DOT has general monitoring and enforcement authority re-
 garding radioactive waste transport.⁵⁵ Maritime shipments of
 wastes are subject to Coast Guard inspection and enforcement.⁵⁶
 ERDA shipments are exempt from Coast Guard regulatory jurisdiction
 if accompanied by ERDA personnel.⁵⁷ The FAA's present role in
 waste shipment regulation is negligible and will probably remain
 so; neither NRC nor ERDA contemplates the use of air shipment in
 waste management operations.

Federal-State Relations

The role of individual states in waste management regulation is an issue of increasing importance. This issue underlies much of the previous discussion.

A number of states have already challenged the notion of exclusive federal jurisdiction over radioactive waste management regulation. Several of the state nuclear initiatives which have been proposed, including the much publicized but recently defeated California Proposition 13, have contained provisions regarding waste management. The California Legislature has enacted several laws which are intended to impose much milder conditions on nuclear power development in the state than were contained in Proposi-

tion 15. One of these recently enacted laws prohibits any nuclear power plant land use in the state or certification by the State Energy Resources Conservation and Development Commission until

the commission finds that there has been developed and that the United States through its authorized agency has approved and there exists a demonstrated technology or means for the disposal of high-level nuclear waste.⁵⁸

Michigan's Governor informed ERDA during the 1976 summer, in response to ERDA investigation of disposal sites in the state, that

... before any further negotiations, discussions, or binding decisions or contracts are made, I, as Governor, must be assured in writing that a disposal site will not be selected without approval of the state.⁵⁹

Also this summer, Connecticut passed legislation prohibiting the transportation of commercial radioactive waste within or through its boundaries unless the Connecticut Commissioner of Transportation has first issued a permit authorizing its shipment. The law includes strong inspection and enforcement provisions, including civil fines of up to \$10,000 for each violation.⁶⁰

The federal government is constitutionally established as a government of limited powers. All authority not delegated in the U.S. Constitution is expressly reserved to the several states by the 10th Amendment. In general, the states retain broad authority to legislate and to regulate activities within their respective borders in order to assure public health and safety. Land use is also a subject that is traditionally considered within primary state control. Therefore, state regulation of radiological hazards in general, and radioactive waste in particular, would clearly be appropriate and necessary, but for two qualifications. The first

qualification is that, under the Commerce Clause, state regulation⁶¹ must not constitute an undue burden on interstate commerce;

the second is that, under the Supremacy Clause, state regulation⁶² must not conflict with valid federal legislation or regulation.

Of the two, the preemption issue is more important in view of the existing federal legislation and regulatory scheme. Based on the pervasiveness of congressionally mandated federal regulation of radioactive waste management, as previously discussed, and the congressional intent expressed in legislative histories of the relevant acts, it is reasonable to conclude that current federal law (including the Agreement States program) would preempt attempts to regulate radioactive waste operations for the purpose of controlling radiological hazards.⁶³

Such a conclusion is supported⁶⁴ by Northern States Power v. Minnesota in which the U.S. Supreme Court affirmed the 8th Circuit Court of Appeals holding that the AEC-prescribed limits on radioactive effluents from nuclear power plants preempt state regulation, and that states cannot impose more stringent radiological standards.

However, state land use controls which in effect zone out radioactive waste operations from certain areas may still be valid, depending on the purpose of the exclusion and the specific character of the activity excluded. Probably, a state or locality, acting pursuant to state law, could control the siting of reprocessing and fuel fabrication plants, including temporary radioactive waste storage facilities, as part of a broader scheme to control industrial⁶⁵ development and the siting of major industrial facilities. State disapproval of a site for a nuclear facility must rest on grounds

other than the potential radiological hazard involved. On the other hand, a state or locality probably could not affect the siting of a permanent radioactive waste repository, which is legally required to be on federal land, presently owned or acquired.⁶⁶ Finally, federal safety regulation would preempt state efforts to regulate transportation of radioactive waste to the extent the state's concern is based on safety issues.

The operational reality of federal-state relations in any field is framed by the law, but it is influenced decisively by politics and economics. Whether or not state regulation would be eventually declared federally preempted and hence invalid in a court test, the governor, legislature or people of a state can in many ways effectively resist any activity within the state's borders that is authorized or directed by the federal government. This is true of the location of military installations, such as the Navy's Project Sanguine (now Project Seafare),⁶⁷ and of radioactive waste repositories, such as the AEC's salt formation near Lyons, Kansas.⁶⁸

States interested in participating in the regulatory decision-making process will probably be able to exert their greatest influence at the site-approval stage of a federal licensing process. As long as state claims do not represent pretextual attempts to bar outright these facilities, states must be allowed to assert reasonable influence in siting and other regulatory decisions that will affect the non-radiological safety and welfare of local communities. How serious federal-state conflicts over regulatory jurisdiction with regard to radioactive waste will grow is unclear at this time. Political pressures will doubtless play as forceful a role as legal precedent in the ultimate resolution of whatever conflicts arise.

International Regulation

Activities involving radioactive waste may occur within or beyond the limits of national jurisdiction. Moreover, radioactive waste operations within one nation may have effects beyond that nation's jurisdiction, either in another nation or in an area outside the jurisdiction of any nation, such as the high seas, the deep seabed, Antarctica or in space. Radioactive waste management activities occurring or having effects beyond U.S. jurisdiction may, if conducted by U.S. nationals, be subject to U.S. regulation, or regulation by other affected nations, or various forms of international regulation, or all three concurrently. The international ramifications of radioactive waste are important to consider especially in view of existing practices regarding ocean dumping of low-level waste and future options for seabed and ice sheet disposal of HL waste.

Nationally, under the Marine Protection, Research, and Sanctuaries Act of 1972,⁶⁹ EPA has authority to issue permits for the transportation of all materials (except dredged material, which is the jurisdiction of the Secretary of the Army) for the purpose of dumping them in the territorial waters of the United States.⁷⁰ Dumping of HL waste is specifically prohibited,⁷¹ but the dumping of TRU waste is not. (The U.S. government has nonetheless enforced a moratorium on TRU waste dumping since 1970).⁷² Neither EPA nor ERDA has yet publicly interpreted "dumping" to include the deep seabed emplacement option, but the agency staffs are now reconsidering the matter. EPA has claimed that it does have licensing jurisdiction over such action.⁷³ Both the meaning of dumping and EPA's assertion of jurisdiction are subject to dispute, and may

require Congressional or judicial clarification.

As a brief digression at this point, it is worth mentioning that EPA has parallel authority to control fresh water pollution through a different permit-issuing program under the Federal Water Pollution Control Amendments of 1972.⁷⁴ HL waste "discharge" is prohibited.⁷⁵ No one of course contemplates using U.S. fresh waters for post-fission waste disposal purposes, but the prevention of radionuclide migration from temporary storage facilities or permanent repositories to aquifers is one of the primary technological goals of radioactive waste management. EPA has not, however, demonstrated any intention to license radioactive waste facilities on land. It has in fact maintained that NRC and ERDA have sole jurisdiction over discharges of source, by-product, and special nuclear materials, a position recently affirmed by the Supreme Court.⁷⁶ It is not clear what effect, if any, this decision will have on EPA's claim for permit-issuing power over possible ERDA deep seabed emplacement, where again only source, by-product, and special nuclear materials are present.

Internationally, the U.S. is a party to a number of multilateral agreements relating to U.S. radioactive waste policy. Two have major significance. The 1958 United Nations Law of the Sea Convention on the High Seas,⁷⁷ applying to all parts of the sea not included in the territorial waters of a nation, provides the foundation for modern international attempts to protect the maritime environment. The High Seas convention makes it the general duty of nations to exercise "reasonable regard to the interests of other states in their exercise of the freedom of the high seas."⁷⁸ Three more specific obligations apply directly to the problem of marine

pollution: 1) nations are to promulgate their own regulations so as to prevent pollution "from the exploitation and exploration of the seabed and its subsoil";⁷⁹ 2) "taking into account" any international regulations, nations "shall take measures to prevent pollution of the seas from the dumping of radioactive waste";⁸⁰ and 3) nations have a duty to "cooperate with the competent international organizations [here, the IAEA] in taking measures for the prevention of pollution of the seas or air space above."⁸¹ These High Seas Convention obligations are by no means stringent. Obviously, the U.S. and other nations can choose to interpret the "reasonable regard" standard strictly or loosely and then behave accordingly. The requirements to take into account international regulations and to cooperate with IAEA, however, imply at least consultation with IAEA prior to implementing deep seabed emplacement of HL waste. (Ocean dumping of TRU waste is apparently not considered an acceptable U.S. option, although other nations are continuing to dump low-level waste and it is not clear whether some of this waste is TRU contaminated.)

In 1975 the London Convention on Prevention of Marine Pollution by Dumping of Wastes and Other Matter⁸² entered into force. It prohibits, except in the case of emergencies at sea and other emergencies for which no other solution is feasible, "dumping" of HL waste at sea.⁸³ An appropriate national authority is required to monitor ocean dumping of low-level radioactive waste; reports on each dump must be made to it.⁸⁴ Regional cooperation is encouraged, but enforcement is specifically a national matter.⁸⁵ The "emergency" exceptions have been criticized as possibly allowing parties a means of exempting themselves from the dumping prohibition. While the parties probably did not intend "dumping" to include deep sea

emplacement, the issue is not closed due to subsequent treaty interpretations.

The United States is also a party to the 1959 Antarctic Treaty,⁸⁶ which specifically prohibits the "disposal" of radioactive waste in Antarctica.⁸⁷ Each of the parties is entitled to designate observers, who have complete freedom of access at all times subject only to the jurisdiction of their nation, to monitor compliance with this ban.⁸⁸ The parties further agree "to exert appropriate efforts, consistent with the Charter of the United Nations," to insure that no one engages in radioactive waste disposal in the Antarctic.⁸⁹ Hence, international treaty law clearly prohibits use of the Antarctic ice sheet as a permanent repository for HL waste to parties to the Treaty. However, the existing treaty expires in 1989⁹⁰ and, the ice sheet disposal option will probably be considered in negotiating any extension.

The outcome of the current Law of the Sea Conference may also affect the prospects for seabed disposal. The Informal Single Negotiating Text, which is the basis of the negotiations, contains provisions which would clarify and reinforce existing international legal norms affecting marine pollution generally. The Text would establish an International Seabed Authority to regulate development of seabed resources. Although primarily concerned with resource development, the competence of the Authority would seem necessarily to extend to seabed disposal of radioactive waste, at least to the extent of assuring non-interference of any proposed disposal activity with existing or possible future seabed resources exploration, development or production activity.

Finally, other governments may specially object to any U.S. disposal of radioactive waste of military origin in an area beyond its national jurisdiction. The motive for such an objection may be general concern with the impact on the environment or political concern with the military origin of the waste involved.⁹¹

Research and Development

The Energy Reorganization Act left ERDA with principal research and development authority for military and commercial radioactive waste technology.⁹² NRC and EPA conduct essentially confirmatory research and studies aimed at improving the quality of their regulations. NRC recognizes ERDA's broader research capabilities and must necessarily rely on much of the data furnished by ERDA without confirmation. Such a separation is important so that NRC, as an independent regulatory agency, does not find itself in a position where it is being asked to license technology it developed itself.⁹³

ERDA's Fiscal Year 1977 budget reflects the dramatically growing Congressional concern over finding technological answers for radioactive waste management problems. The combined military and commercial programs have received a three-fold increase in funds from approximately \$30 million to about \$90 million.⁹⁴ Commercial waste programs within this budget have been expanded by a factor of five, from about \$12 million to over \$60 million.⁹⁵ ERDA summarizes the priorities in its budget as follows:

The ERDA FY 1977 commercial waste budget is keyed to providing input for decisions on reprocessing, waste forms and storage modes for high-level radioactive waste. The selection of specific sites and development of repositories for terminal storage is considered the major item in a greatly expanded ERDA Fiscal Year 1977 waste budget. For earlier necessary or desirable

waste management activities, technology is either in use or considered well developed, i.e. the basic technical principles are clearly understood and data needed for design are available. Efforts to reduce these principles to practice, especially in high-level liquid waste solidification, are also the subject of expansion in the FY 1977 budget. All of the foregoing effort has been keyed to the expected needs of the nuclear fuel cycle industry.⁹⁶

ERDA, then, plays the role of principal researcher, in addition to its roles as major manager, and self-regulator of most of its own management activities. Since "research and development" in the Atomic Energy Act includes demonstration projects,⁹⁷ ERDA also has the authority to demonstrate the feasibility of ultimate deep geologic disposal (the present favored technology). ERDA decisions made in these four areas seem insulated from NRC regulatory control. Yet they profoundly affect the direction of the national waste management effort and policy-making in this area.

Implementation

The Federal Energy Resources Council, in cooperation with several agencies, including the nuclear ones, recently issued a status report on waste management, in which it listed four requirements for proper implementation:

- The thorough reviews mandated by the National Environmental Policy Act.
- The promulgation and satisfactory compliance with generally applicable environmental standards and criteria issued by the Environmental Protection Agency.
- Compliance with licensing criteria and requirements of the Nuclear Regulatory Commission.
- Opportunities for full public participation.⁹⁸

The National Environmental Policy Act⁹⁹ (NEPA) is an omnipresent federal policy-making mechanism. It requires every Federal

agency to prepare an Environmental Impact Statement (EIS) in connection with" . . . every recommendation or report on proposals for legislation and other major Federal actions significantly affecting the quality of the human environment. . . ."100 Each EIS must contain ". . . a detailed statement by the responsible officials on--

- (i) the environmental impact of the proposed action,
- (ii) any adverse environmental effects which cannot be avoided should the proposal be implemented,
- (iii) alternatives to the proposed action,
- (iv) the relationship between local short-term uses of man's environment and the maintenance and enhancement of long-term productivity, and
- (v) any irreversible and irretrievable commitments of resources which would be involved in the proposed action should it be implemented."101

It must be prepared in consultation with and must include the comments of ". . . any Federal agency which has jurisdiction by law or special expertise with respect to any environmental impact involved."

NEPA does not require agency rectification of environmental harm from a proposed project. But any EIS not prepared in accordance with the above requirements may be deemed "inadequate" by a court. An agency may then be required to draft a new EIS. EIS's, when published, become part of the public record. EPA, sometimes in conjunction with the Council on Environmental Quality, reviews and comments on all EIS's.¹⁰² Public sentiment and/or EPA ratings can be important factors in Congressional decisions to fund agency proposals or in court hearings on whether or not to enjoin agency actions.

All operations in the back of the nuclear fuel cycle which are federally licensed or contracted for constitute "Federal actions,"

as does the promulgation of regulations designed to control these operations. The question of which contemplated actions are "major" and likely to "significantly" affect the environment are more complicated. But it is clear that, prior to implementation, ERDA and NRC must prepare "generic" EIS's for their respective management and regulatory programs in regard to radioactive waste.

ERDA's present time schedule for implementing commercial waste management technologies assumes that commercial reprocessing may start as early as late 1977. In addition,

--[T]he ERDA waste management program is currently directed at meeting the following targets: high level waste solidification technology available for startup of the commercial plants in 1983; at least one terminal storage plant ready to receive waste beginning in 1985; technology for handling other wastes from the back end of the fuel cycle available for industrial adoption by 1979; and, finally, technology available by 1984 for package transporting and handling spent fuel, in the event it is later determined not to re-process or otherwise recycle plutonium and/or uranium.¹⁰³

The above schedule allows 6 years, rather than 5, for solidification. Thus, either an adjustment in ERDA's schedule or a revision of NRC regulations is necessary. The ERDA schedule is keyed to a NRC decision on plutonium recycle in 1977.¹⁰⁴

To meet the schedule, NRC must complete its Generic Environmental Impact Statement on the Use of Recycle Plutonium in Mixed-Oxide Fuel in LWR's (GESMO), complete an extensive public hearing on the subject, and issue final regulations governing the licensing of commercial reprocessing plants. The health, safety, and environment section of GESMO was scheduled for completion on August 30 of this year. The safeguards supplement should be issued within a few months. The current GESMO schedule has thus already slipped several months behind what was originally proposed.

ERDA's EIS on commercial HL waste management is to follow GESMO. Completion of a draft for public comment is currently set for the spring of 1977, but there may well be some slippage in this schedule.

Federal decision-making concerning reprocessing and recycling suffered a recent setback in NRDC v. NRC.¹⁰⁵ In that case, the Second Circuit Court of Appeals set aside an NRC order allowing construction and other preparatory work to begin on a New York mixed-oxide fuel fabrication plant. The court noted that NRC had adopted an interim licensing procedure to maintain commercial momentum in recycling while its GESMO was incomplete. This procedure, it found, failed to satisfy NEPA, specifically because of the inadequate treatment of alternatives to plutonium recycle and of hazards of theft, diversion, and sabotage.¹⁰⁶

There is a further criticism of GESMO and the issues as presently framed in the NRC plutonium recycle decisional process: the GESMO will not fully discuss environmental impacts since it will not itself include a complete discussion of how the radioactive waste from recycling operations will be safely managed.¹⁰⁷ Nor are the radioactive waste EIS's now under preparation to be considered along with GESMO in the commercial reprocessing decisional process.

Other legal developments during the summer of 1976 have made radioactive waste an important unresolved issue in the commercial power reactor licensing process. In July the D.C. Circuit Court of Appeals ordered NRC to reconsider the Vermont Yankee reactor operating license and the procedure used to issue the license.¹⁰⁸ NRC's generic approach to evaluating radioactive waste hazards for individual reactors was held to be ineffective, "incremental decisionmaking" precluded by NEPA; and NRC's calculation of waste

hazards as "insignificant" in reactor operations was termed "arbitrary and capricious," because its procedures for so determining were insufficient and because it had not provided any support for such an evaluation.¹⁰⁹

On the same day, the D.C. Circuit Court of Appeals ruled that the Commission must undertake "consideration of waste disposal and other unaddressed fuel cycle issues, and restrike the cost-benefit analysis" in the reactor licensing proceedings for the Consumers Power Midland Plant in Michigan.¹¹⁰ The primary holding of this case required the inclusion in the licensing proceedings of energy conservation as an alternative to the proposed construction of a new power plant. The court required the NRC to take the initiative in analyzing these subjects rather than passively reacting to the issues when they are raised by intervenors in licensing proceedings.

The Natural Resources Defense Council (NRDC) then filed a petition with the NRC requesting the adoption of rules for the implementation of the Vermont Yankee and Midland decisions.¹¹¹ On August 16, in response to the petition, the NRC reopened the rulemaking proceeding on the Environmental Effect of the Uranium Fuel Cycle.¹¹² It suspended issuance of any new full-power operating licenses, construction permits, or limited work authorizations at least until the promulgation of an interim rule on the matter. The earliest possible date of such promulgation was cited as December, 1976. In short, a national moratorium on nuclear power growth is in effect.

By about September 30 NRC plans to have completed a new environmental survey on the probable contributions to the aggregate

environmental effects of a nuclear power reactor that are attributable to the reprocessing and waste management stages of the fuel cycle. It remains to be seen exactly what sort of consideration of the reprocessing and waste management issues at the reactor licensing stage will be deemed adequate and not "incremental."

ERDA has said very little to date about implementation schedules for management of ERDA's military waste. (Congressional hearings are scheduled for later this year on the subject.)¹¹³ NRDC

petitioned NRC in July, 1975 to license ERDA's proposed construction of several new HL waste storage tanks at Hanford and Savannah River and a calcined solids storage facility at Idaho Falls.¹¹⁴ NRC

denied this petition, taking the position that it had no statutory authority to license these facilities since they were not intended for long-term storage. ERDA has denied the legal necessity of preparing an EIS on these facilities on the grounds that they do not constitute major federal actions within the meaning of NEPA. It claims that its consideration of these new facilities in its reports on waste operations at these three sites is enough.

The NRDC has recently petitioned NRC to adopt interim regulations governing disposal of low-level radioactive waste (including TRU waste) and to prepare a programmatic EIS on this aspect of waste management.¹¹⁵ NRC has not yet issued a disposition of this petition. NRC's waste classification effort could conceivably redefine HL waste to include some or all TRU waste. In any case, NRC's promulgation of the 1974 AEC proposed TRU waste regulation must await action on the above petition.

On the horizon is the EIS which will be necessary for the planned pilot federal HL waste repository. ERDA intends to incorporate

this demonstration in its programmatic statement on commercial HL waste management. Nevertheless, as discussed above, ERDA seems to be planning to use HL waste from non-commercial sources in its demonstrations, thereby avoiding the necessity of NRC licensing of such demonstrations.

A reconsideration of the "demonstration" value of pilot plants for permanent repositories, mentioned above, might be used to accelerate implementation. Basically, an elimination of some "demonstration" time could reduce the time required for implementation of a full-scale repository.

Important events on the federal implementation of a radioactive waste management program are set forth in the Energy Resources Council status report, included as Appendix A to this chapter. It is important to note, however, that the schedule of dates now appears unrealistically optimistic.

Conclusions

The U.S. inventory of radioactive waste has two sources -- commercial and military nuclear activities. Though military wastes presently comprise by far the greatest proportion of the most toxic waste, the future management challenges are comparable in their overall importance, though the difficulties differ somewhat.

1. In their statements of basic policy goals, federal officials have thus far adopted a primarily technological perspective. "Safe management" has essentially meant "isolation and containment." More recently, policy makers have mentioned, however tangentially, other factors such as risk/cost analysis, institutional stability, public confidence, consolidation of management responsibilities, and inter-agency and international coordination. NRC is leading the

effort to reformulate goals to embrace non-technological as well as technological criteria.

2. The present institutional organization for achieving radioactive waste policy goals has basically three functions: management, regulation, and research and development. Overall management responsibility is divided between the private industry (licensees of NRC and/or of Agreement States) and the federal government (ERDA and its contractors). Commercial HL waste is to be managed in the short-term by licensees and in the long-term by ERDA. Military HL waste is solely a federal responsibility; ERDA manages plutonium production facilities that create HL waste, and DOD is responsible for managing spent fuel elements from naval propulsion programs until they are turned over to ERDA. Commercial TRU waste is presently managed by licensees in the short- and long-term. NRC has proposed regulations, however, that will shift long-term management responsibility to ERDA. Present military TRU waste is managed solely by the federal government, primarily by ERDA.

3. Within the federal government, the landscape of regulatory authority appears rather cluttered. It is composed mainly of NRC and ERDA, but other federal agencies, state governments, and international bodies also have regulatory claims, though some are of uncertain legitimacy or reach. Primary authority for setting criteria or standards for management operations rests with NRC and ERDA in their respective areas of regulatory responsibility. EPA intrudes on this scene, however, with its authority to set generally applicable environmental standards for radiation exposure and to give guidance to all federal agencies in the formulation of radiation standards.

The heart of regulatory activity in waste management is the licensing/approval function. Responsibility for licensing commercial HL waste operations rests solely with NRC. This authority appears to cover, indirectly, any ERDA research and development storage facility that receives commercial HL waste.

Military HL waste management is approved in the short-term by ERDA, which conducts its monitoring and enforcement activities through contractual, rather than regulatory mechanisms. For the long-term, NRC has licensing authority encompassing military HL waste storage facilities not used for research and development, excluding ERDA facilities existing at the time the Energy Reorganization Act of 1974 became effective. Thus ERDA retains regulatory authority over its then-existing facilities despite the continued absence of plans to transfer the military HL waste solidified in place at Hanford and Savannah River to ERDA planned, NRC-regulated permanent repositories.

Also, ERDA approves its own site selection, construction and operation of research and development storage facilities; yet here the strong possibility exists that ERDA will ultimately designate some of these sites as successfully-demonstrated final repositories and will then submit them to NRC for licensing, thereby avoiding any timely NRC control over site selection and pre-construction design.

Regulatory authority over commercial TRU waste is exercised by NRC or delegated, wholly or in part, by NRC to Agreement States. The present scheme would be altered, however, by proposed NRC regulations requiring all short-term managers to transfer their TRU waste

to ERDA for long-term management; ERDA or NRC (it is not clear which) would then acquire long-term regulatory authority. If these regulations are adopted, NRC could, if it desired, implement a short-term regulatory strategy which might effectively give it control over long-term regulation. Such a strategy, however, would not infringe upon ERDA's current regulatory jurisdiction over military TRU waste, where ERDA has undisputed short- and long-term authority.

Overlapping the regulatory authorities of NRC and ERDA is DOT's responsibility to insure the safe transport in commerce of hazardous radioactive materials. Cooperative arrangements between DOT and AEC (applicable now to both ERDA and NRC) divide responsibilities for establishing criteria for packaging and handling waste and allot sole responsibility for licensing of waste transport to the nuclear agencies, who agree to enforce their respective standards and applicable DOT ones as well.

4. The states' authority to regulate waste management operations is basically preempted by the federal government. Though challenges are continuing, the existing law is that states may only regulate non-radiological aspects in a way that does not unduly interfere with federal promotion and regulation of nuclear energy. Political pressures from concerned states can, however, be quite effective in altering the federal government's behavior, and there is ample room for state (and citizen) participation in federal decisional processes.

5. Ocean use options involve additional national and international environmental institutions. Nationally, EPA has permitting authority for ocean dumping of TRU waste, though the U.S.

does not currently employ such an option. Dumping of HL waste is prohibited, though probably this would not include deep seabed emplacement. EPA has also claimed permit-issuing authority over any deep seabed waste emplacement. Internationally, formal agreements to which the U.S. is a party place no unreasonable constraints upon U.S. radioactive waste decisions, but they do require a balancing of other nations' interests. High-level waste "dumping" is prohibited (with "emergency" exceptions), though here again it is doubtful that the term includes deep seabed emplacement. No effective international monitoring or enforcement institution currently exists. The outcome of the Law of the Sea Conference, which is presently under way, must be taken into account if the U.S. government decides to pursue any of the "ocean options" for radioactive waste disposal. Finally, Antarctica is legally off-limits for any type of radioactive waste disposal.

6. ERDA dominates waste management research and development. NRC and EPA contribute mainly confirmatory research in areas of particular regulatory interest. ERDA thus occupies the dual position of chief researcher and major manager of high- and low-level waste (as well as that of self-regulator of much of its own management activities). A potential problem with such an institutional arrangement is that the managers within ERDA may find themselves forced into management strategies dictated by their research counterparts, instead of being able to direct research efforts according to the necessities of waste management operations.

7. The schedule for implementing current radioactive waste policy goals seems unrealistically rapid. The existing decoupling of NEPA reviews of commercial reprocessing and commercial waste

operations seems unwise as an approach to the strategic decisions involved in post-fission fuel cycle management. If maintained, the decoupling of two such important and strongly interrelated subjects as commercial plutonium management and commercial waste management may prevent a decisional process in which the relevant benefits, costs and risks are comprehensively assessed. Fragmentation of the decisional process regarding post-fission nuclear fuel cycle management may well fall short of NEPA requirements, and hence be vulnerable to legal challenge.

* * *

Existing institutional arrangements for management and regulation of radioactive waste are inadequate for the future.

APPENDIX A

(Excerpt from Federal Energy Resources Council Status Report on the Management of Commercial Radioactive Nuclear Wastes, May 10, 1976)

- ° The timetable for major events in the management of commercial radioactive wastes including actions already taken:

1976

- ERDA announced an expanded program to develop Federal repositories in deep geologic formations for terminal storage of radioactive waste.
- ERDA identified candidate high-level waste solid forms for terminal storage.
- President's FY '77 Budget requested, and the Joint Committee on Atomic Energy has approved, funds to accelerate programs for:
 - selection of sites and construction of storage facilities, and
 - development of selected commercial scale solidification process technology and process designs
- ERDA established a terminal storage facility program management office at Oak Ridge, Tennessee.
- ERDA has issued for public review the Technical Alternatives Document.

- NRC will circulate preliminary revised waste form and packaging regulations for comment.
- EPA/NRC, with the assistance of USGS, will evaluate commercial low-level waste land burial sites and will determine criteria on radioactivity levels for wastes to be delivered to each site.
- ERDA will issue a draft generic environmental impact statement on reprocessing.

1977

- ERDA will issue a draft generic environmental impact statement on the management of commercial radioactive wastes for public review and comments.
- EPA will determine general performance criteria for establishment of new low-level waste land burial sites.
- NRC will publish an environmental impact statement for revised waste management regulation.
- ERDA will publish a final environmental impact statement on reprocessing and announce a decision thereon.
- NRC will announce its decision on plutonium recycle.

- ERDA will publish a final generic environmental impact statement on management of commercial radioactive wastes.

1978

- NRC will publish final regulations for waste form and packaging criteria.
- ERDA will announce a decision on waste forms, storage modes, and packaging criteria to be used as basis for designing terminal storage facility.
- EPA will establish general environmental standards applicable to high-level waste management.
- ERDA will select site(s) for the underground excavation phase of the radioactive waste geologic program. (This action will be subject to the appropriate site-specific environmental impact statement.)
- NRC will establish criteria for long-term care for new low-level waste burial sites.

1979

- NRC will establish site selection criteria for new low-level burial grounds.

1985

- ERDA will start receiving solidified waste in pilot plant operations in a geologic terminal storage facility.

- * The dates shown for major regulatory actions are estimates provided by the NRC. The NRC, an independent regulatory agency, points out that these dates cannot be predicted with certainty. Based on experience with regulatory process lead time, however, the time allowed in the program should prove sufficient to allow for full decision-making processes, including public participation.

MAJOR REGULATIONS ESTABLISHED BY NRC				
Waste Type - Source	Industry (or ERDA) Strategy Estab.	Waste Producing Facilities	Offsite Storage/Disp.	Det'd Reg. Criteria Estab. by NRC
HLW				
- Commercial	YES	YES (d)	YES	PART
- ERDA	PART	---	(YES)	NO
Hi-y TRU				
- Commercial	NO (in PREP.)	YES	YES (a)	NO (a)
- ERDA	PART	---	(YES)	NO
Lo-y TRU				
- Commercial	PART	YES	YES (a)	PART (a)(e)
- ERDA	PART	---	(YES)	NO
LLW (non-TRU)				
- Commercial	YES	YES	YES (b)	PART (e)
- ERDA	YES	---	(YES)	NO
Gases				
- Commercial	NO	YES	YES	NO
Mill Tailings	NO (or PART)	YES	NO (c)	PART
Decom Facilities				
- Commercial	NO (or PART)	YES	YES	PART
- ERDA	NO (or PART)	---	---	---

- a. Proposed regulation on TRU gives ERDA possession; licensing by NRC was not made specific in the Energy Reorganization Act.
- b. Shared with Agreement States
- c. Based on previous legal interpretations of definitions of source and byproduct materials.
- d. Except specific licensed ERDA facilities.
- e. Shared with EPA.

Footnotes to Chapter 4

1. Hearings on Radioactive Waste Management Before the Subcomm. on Environment and Safety of the Joint Comm. on Atomic Energy, 94th Cong., 2d Sess., vol. 3, 74 (1976) (stenographic transcripts); hereinafter cited as "May hearings."

2. Hearings on Storage and Disposal of Radioactive Waste Before the Joint Comm. on Atomic Energy, 94th Cong., 1st Sess. 18 (1975); hereinafter cited as "November hearings."

3. Address by Dr. Carl W. Kuhlman, Assistant Director for Waste Management, Division of Nuclear Fuel Cycle and Production, ERDA, Atomic Industrial Forum Uranium/Nuclear Fuel Conference, Mar. 21-24, 1976.

4. May hearings, vol. 1, 34.

5. Memorandum from Kenneth Chapman, Director Office of Nuclear Materials Safety and Safeguards for the NRC Commissioners, "Status Report--Waste Management Program," April 22, 1976, 6.

6. Id. at 3, 4.

7. Atomic Energy Act of 1954, 42 U.S.C. §§ 2011-2296 (1970).

8. Energy Reorganization Act of 1974, 42 U.S.C. §§ 5801-5891 (Supp. IV, 1974).

9. See text accompanying fn. 35.

10. 10 C.F.R. § 50 APP. F2. (1971) (policy relating to the siting of fuel reprocessing plants and related waste management facilities).

11. ERDA manufactures the nuclear explosive components of nuclear weapons, which DOD then assembles.

12. 39 Fed. Reg. 32921 (1974).
13. Hearings on Low-Level Radioactive Waste Disposal Before a Subcomm. of the House Comm. on Government Operations, 94th Cong., 2d Sess., 209 (1976); hereinafter cited as "March hearings."
14. Interview with Robert Will, Director, Division of Radiation Control, State of Washington, in Olympia, Wa., July 20, 1976.
15. 42 U.S.C. §§ 2073, 2093, 2095, 2111, 2133, 2134, 2201 (1970).
16. Ibid; 42 U.S.C. §§ 5814(c), 5841(f) (Supp. IV, 1974).
17. 42 U.S.C. § 2021(h) (1970); transferred by Reorganization Plan No. 3 of 1970 § 2(7), 42 U.S.C. § 4321 (1970).
18. Reorganization Plan No. 3 of 1970 § 2(6), 42 U.S.C. § 4321 (1970).
19. Address by William Rowe, EPA, at International Symposium on the Management of Wastes from the LWR Fuel Cycle, Denver, Colo., July 12, 1976.
20. 10 C.F.R. 50 App. F3 (1971).
21. 10 C.F.R. § 20.302(a) (1971).
22. 10 C.F.R. § 20.302(b) (1971).
23. 10 C.F.R. 50 App. F1 (1971).
24. See fn. 12.
25. 42 U.S.C. 5842(3) (Supp. IV, 1974).
26. Interview with Alex Perge, Office of Waste Management, Division of Nuclear Fuel Cycle, ERDA, in Germantown, Md., June 28, 1976.
27. ERDA Manual Chapter 0511.

28. ERDA Manual Chapter 0524.
29. ERDA Manual Appendix 0502.
30. 42 U.S.C. § 2140 (1970).
31. 42 U.S.C. § 5842(4) (Supp. IV, 1974).
32. Brief for National Resources Defense Council, Inc. Before ERDA in re [NRC] Licensing of ERDA's Projects... (July 28, 1975).
33. See, e.g., Brief for NRDC... (July 28, 1975).
34. See p. 3-30.
35. 42 U.S.C. § 2021 (1970).
36. 42 U.S.C. § 2021(j) (1970).
37. March hearings, 206-7.
38. 42 U.S.C. § 5842(4) (Supp. IV, 1974).
39. From discussions with NRC personnel.
40. Interview with Richard Cunningham, NRC, in Bethesda, Md., June 1976.
41. Appendix F of 10 C.F.R. 50, which defines HL waste, was adopted in 1971; the Energy Reorganization Act was passed in 1974.
42. See p. 3-38.
43. U.S. NRC Release No. 76-98, April 23, 1976, 2, 3.
44. 18 U.S.C. §§ 831-5 (1970), 49 U.S.C. 1655(e)(4) (Supp. V, 1975); 46 U.S.C. § 170 (1970), 49 U.S.C. 1655(b) (Supp. V, 1975); 49 U.S.C. §§ 1421-1430 and 1472(h) (1970), 49 U.S.C. 1655(c) and (d) (Supp. V, 1975); 49 U.S.C. 1801-1812 (Supp. V, 1975).
45. Memorandum of Understanding between DOT and AEC, 38 Fed. Reg. 10437 (1973).

46. Ibid.
47. 10 C.F.R. part 71.
48. 10 C.F.R. § 71.12 (1975).
49. See text accompanying fn. 16.
50. From discussions with NRC personnel.
51. Address by D.A. Nussbaumer, NRC, Denver Symposium, July 14, 1976.
52. 42 U.S.C. §§ 2201(b), (c), (o), 2271-2282 (1970).
53. See, e.g., 10 C.F.R. §§ 30-52, 40.62, 70.55, 10 C.F.R. §§ 19.30, 20.601, 30.61-30.63, 40.71, 40.81, 55.50.
54. ERDA Procurement Instructions Subpart 9-7.50, 9-7.5004-12.
55. See fn. 37, particularly 18 U.S.C. § 835 (1970) and 49 U.S.C. 1808-1810 (Supp. V, 1975).
56. 46 U.S.C. § 170 (1970).
57. 46 C.F.R. § 146.02-8(b) (1973).
58. California Assembly Bill No. 2822, June 3, 1976.
59. Letter from Governor William G. Milliken to Robert C. Seamans, Administrator, ERDA, July 8, 1976.
60. Conn. Public Act No. 76-321 (2 Nuc. Reg. Rep. ¶ 20,031 (June 18, 1976)); see also Miss. Laws of 1976 Chapter 469 (2 Nuc. Reg. Rep. Report Letter No. 52 (July 23, 1976)).
61. U.S. Const. art. I, § 8, cl. 3.
62. U.S. Const. art. VI, cl. 2.
63. See 42 U.S.C. § 2021(k) (1970); see generally Hearings on Federal-State Relationships in the Atomic Energy Field Before the Joint Comm. on Atomic Energy, 86th Cong., 1st Sess. (1959).
64. 447 F.2d 1143 (8th Cir. 1971), aff'd without opinion,

Dumping of Wastes and Other Matter, Dec. 29, 1972 (1975), T.I.A.S. No. 8165; for text see 11 I.L.M. 1291 (1972).

83. Convention on the Prevention of Marine Pollution, art. IV, para. 1.

84. Convention on the Prevention of Marine Pollution, art. VI.

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86. Antarctic Treaty, Dec. 1, 1959 (1961), 1 U.S.T. 794, T.I.A.S. No. 4780, 402 U.N.T.S. 71.

87. Antarctic Treaty, art. V.

88. Antarctic Treaty, art. VII.

89. Antarctic Treaty, art. X.

90. Antarctic Treaty, art. XII.

91. See generally D. Deese, Law of the Sea and High Level Radioactive Waste Disposal: A Potential Geologic Option Under the Deep Seabed? March, 1976 (unpublished thesis for Fletcher School of Law and Diplomacy, Tufts University).

92. 42 U.S.C. §§ 5814(c), 5813(1) (Supp. IV, 1974); see also November hearings 27, 31.

93. See S. Rep. No. 1252, 93d Cong., 2d Sess. 34-5 (1974).

94. Address by Dr. Carl W. Kuhlman, Assistant Director for Waste Management, Division of Nuclear Fuel Cycle and Production, ERDA, Denver Symposium, July 13, 1976.

95. Ibid.

96. ERDA Program Implementation Document, ERDA's Program for Management of Radioactive Waste from Commercial Nuclear Power Reactors, summary at 16 (1976).

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103. May hearings, vol. 2, 3-4.
104. See App. A, p. 4-34.
105. Natural Resources Defense Council, Inc. v. NRC, Nos. 75-4276 and 75-4278 (2d Cir., May 26, 1976).
106. Ibid.
107. AEC, Draft Generic Environmental Statement on the Use of Recycle Plutonium in Mixed Oxide Fuel in LWR's (GESMO), 1974.
108. Natural Resources Defense Council v. NRC, Nos. 74-1385 and 74 1586 (D.C. Cir., July 21, 1976).
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110. Aeschliman v. NRC, Nos. 73-1776 and 73-1867 (D.C. Cir. July 21, 1976).
111. See Federal Register, August 16, 1976, 34710.
112. Id. at 34707.
113. May hearings, vol. 3, 93.
114. Brief for NRDC ... (July 28, 1975).
115. See Memorandum of Points and Authorities in Support of NRDC's Petition for Rulemaking and Request for a Programmatic Environmental Impact Statement Regarding NRC Licensing of Disposal of Low-Level Radioactive Wastes (August 10, 1976).

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65. See N. Calif. Ass'n to Preserve Bodega Head and Harbor, Inc. v. Pub. Util. Comm'n, 61 Cal.2d 126, 390 P.2d 200, 37 Cal. Rptr. 432 (1964).

66. See fn. 20 and accompanying text.

67. This project involves the development of an extremely low frequency (ELF) communications system designed to provide military communications for U.S. Strategic Forces, particularly submarines.

68. See T. Lash, J. Bryson, and R. Cotton, Citizens' Guide: The National Debate on the Handling of Radioactive Wastes from Nuclear Power Plants 34-41 (2d printing 1975).

69. 33 U.S.C. §§ 1401-1444 (Supp. V, 1975).

70. 33 U.S.C. § 1412.

71. Ibid.

72. November hearings, 49.

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74. 33 U.S.C. §§ 1251-1376 (Supp. V, 1975).

75. 33 U.S.C. § 1311(f).

76. Train v. Colorado Public Interest Group, 44 U.S.L.W. 4717 (U.S. June 1, 1976).

77. Convention on the High Seas, April 19, 1958 (1962), 2 U.S.T. 2312, T.I.A.S. No. 5200, 450 U.N.T.S. 82.

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80. Convention on the High Seas, art. XXV, para. 1.

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Chapter 5

INSTITUTIONAL ALTERNATIVES

A major radioactive waste problem already exists in the United States. The nation is irreversibly committed to dealing with this waste problem in some fashion, now and in the future. The technical parameters and size of the problem will change, and it will expand more or less rapidly with continued use of nuclear fuel for electric power production. Radioactive waste has not yet caused substantial and irreparable injury to man or the environment, although costly mistakes have occurred. We are still free to manage the problem in a variety of different ways. Our management options are far broader than the usual shopping list of "technical alternatives." No irreversible institutional commitments have been made. And yet, as chapters 3 and 4 show, institutions which will be adequate for safe management of radioactive waste in the future are not now in place.

This chapter, therefore, discusses alternatives available for modifying old and developing new institutional arrangements that are needed to provide reasonable assurance of the safe management of post-fission radioactive waste in the U.S. in the decades ahead. It is important to emphasize that institutions capable of managing changing problems in a dynamic world must evolve themselves. There is no set of arrangements that will be appropriate in every situation and for all time. In exploring institutional alternatives for radioactive waste management and regulation, therefore, we are seeking practical arrangements for the next few decades, not a

utopian model for the lifetime of the potential radiological hazard. We must frankly recognize that whatever recommendations emerge from the ensuing analysis, will, if adopted, sooner or later prove to be inadequate to meet the challenge now posed by radioactive waste -- just as the institutions now in place are in urgent need of repair.

Policy Goals

Stated objectives of public policy are notorious for their emptiness. High public officials may declare that the overarching goal of U.S. radioactive waste policy is "safe management." Scientists may state that our objective must be "isolation" of waste from the biosphere for as long as necessary to prevent "harmful effects" to man and the environment. However, "safety" is not an easily defined area. "Isolation" is a shorthand way of expressing a complicated and relative concept. And what is deemed to constitute "harm" to man or environment is a judgment based on subjective values as well as objective facts.

Despite their vagueness, policy goals are important guides to action. Lack of content does not necessarily indicate the absence of candor. Ultimately, our goals are defined through a process of political consensus building. The conditions and content of this consensus change over time. Our goals thus embody shared preceptions of what is an appropriate balance of benefits, costs, and risks.

Discussion of future goals of radioactive waste policy is most usefully organized into two types of objectives: technological, and institutional.

Technological Objectives

The technological objectives of radioactive waste management will be relatively straightforward, though not easy to attain. The basic goal is familiar: sufficient isolation of radioactive waste from the biosphere for long enough to guarantee that the risk of harm to man and the environment is acceptably low. This is existing policy for permanent disposition of waste. In the future, however, it is equally important to apply such a criterion to short-term waste management. Thus, the likelihood of accidental leaks should be reduced to very low levels, and there should be appropriate safeguards against intentional malevolent acts at all waste management facilities. The desired isolation for the long-term may be achieved by (1) assured initial emplacement (2) reliable containment, and (3) selection of the best practicable geologic formations.

Uncertainties must be identified and effort channeled into areas where uncertainties can be reduced. For instance, the prediction of geologic upheavals may rest on some largely irreducible sources of uncertainty. But significant improvements in ability to estimate the consequences of such an event may be possible by near-term scientific and technological investigation, and such improvements may be very helpful in determining the efficacy of a particular geologic isolation system.

Institutional Objectives

Technological objectives are not self-implementing. Institutional mechanisms must be developed to achieve them. The evolving nature of the radioactive waste problem demands institutions which are dynamic. Yet the long-term character of the potential hazard requires unprecedented endurance.

Then what or whom should we rely upon to guarantee that radioactive waste will be isolated from the biosphere for the duration of its potential hazard? It may appear that we confront a clear-cut choice of relying either on nature (geologic disposal) or man (permanent storage). Of course, the real choices are between various combinations of man-made and natural mechanisms, but the emphasis in the combination we choose may turn out to be very important in the long-term.

Those favoring primary reliance upon nature may argue that, if the past is any indicator of the future, we can expect political instability and violent social change. Men are fallible and apt to act malevolently. Nuclear warfare is at least as likely to occur as not. In such circumstances, we owe future generations a guarantee of safety from the deadly waste generated by our nuclear endeavors. Therefore, this generation has the responsibility to commit permanently our radioactive waste to a natural place for safekeeping. If this permanent disposition sooner or later will become irreversible -- and with our present technological ability this seems unavoidable -- then so be it.

This line of reasoning has much validity and has significantly influenced current government policy. But it should be questioned. The argument rests on our present ability to accurately predict natural history. An examination of past natural history reveals not only very long periods of stability in certain geologic formations, but also abrupt change in previously stable formations. Extrapolation of future stability based on the past may thus be questioned.

More fundamentally, if we fear human fallibility in the future, how can we be so sure of the correctness of our present

judgments about geological isolation? On the other hand, the prediction of the future course of natural history, while uncertain, is at least based on scientific principles derived from verifiable empirical evidence. This is a good deal more than can be claimed for any prediction of human history. In any event, geologic disposal delegates the function of long-term radioactive waste management from man to nature.

While geologic isolation has obvious attractions, there are advantages in depending on man more than nature for the time being. Man has the capacity to learn and thereby achieve a higher level of technological ability. Man can adapt to changing circumstances. Furthermore, if we rely on man-made systems for waste storage, future generations may be in a position to choose to commit the waste problem to nature if it then appears the wisest course to follow. Nevertheless, some future civilization may well resent our nuclear age if it has no escape from perpetual care for our waste. And a post-fission civilization may have grave difficulty in continuing to care for fission wastes centuries after all benefits from waste generating activities have ceased.

Turning from this rather apocalyptic view of the future, let us now consider an immediate and mundane question. How are radioactive waste policy goals to be achieved? This basic organizational question will be explored by discussion of the three functional areas into which we have previously divided the radioactive waste problem: namely, waste management, safety regulation, and technology development.

Waste Management

Chapter 3 showed, from a technological viewpoint, the desirability of an integrated radioactive waste management framework, and chapter 4 described the presently fragmented management structure.

Now let us reexamine two questions from an institutional viewpoint. First, is there a need for a centralized and integrated management framework for HL waste? And second, does a comparable need exist regarding TRU waste? Thereafter, we will consider a third question: If an integrated management scheme is necessary, what alternative forms are available?

HL Waste

HL waste remains radioactively dangerous for thousands to perhaps a million years. Since human and environmental protection from the radiological hazard of this waste is our primary concern, the organization of any workable HL waste management scheme must be dictated largely by the long-term nature of the management problem. Although commercial and military waste management problems differ in the short-term, the fundamental problem of permanent disposition will be basically the same for HL waste, regardless of its origin. Therefore, in the long-term commercial and military HL wastes are and should be managed under a single authority.

The next issue is whether or not short-term HL waste management operations (temporary storage, treatment, packaging transportation) should be included in an integrated management framework, along with long-term waste repositories. There are a number of advantages to be gained by including short-term commercial and military HL waste operations in a single management authority with long-term repositories. Waste management procedures as a whole are characterized

by a high degree of interdependence. Permanent disposition is deeply affected by treatment, which in turn is affected by waste composition. This type of technological interdependence is an important rationale for integration in any industry (e.g., the petroleum industry). A division of management responsibility would introduce undesirable costs, inefficiencies and risks.

Separation of management responsibilities would provide an incentive for the short-term manager to pass on the maximum amount of cost and risk to the long-term manager, and vice versa, since the operational decisions would be dictated by separate sets of economic considerations. Separate management of short- and long-term operations would also generate unnecessary transaction costs in overcoming organizational obstacles.

On the other hand, an integrated management approach would eliminate the short-term/long-term conflicts which a bifurcated system would encourage. An integrated organization would create incentives for waste management efficiency within established safety criteria; the manager would seek to minimize overall cost rather than to pass on costs and risks. Unified long-term/short-term HL waste management would minimize the danger of self-defeating mistakes since all decisions would be made through a single authority.

Integration of waste management functions is not, however, a virtue in and of itself. It is an attractive organizational solution which grows out of a situation characterized by technological interdependence, a particular economic incentive structure, and the overriding importance of long-term concerns.

It must be remembered that the advantages of any managerial system are necessarily somewhat short-lived. Streamlined manage-

ment in 1976 does not assure the safe disposition of radioactive waste 1000 years from now. But the theory behind this discussion suggests a positive direction in which to move from the present fragmented management structure.

However, the possible disadvantages of a management scheme which would pull short-term commercial and military HL waste management into the same structure that handles permanent disposition must be examined carefully. As for commercial HL waste, the only apparent drawback to short-term/long-term integrated management is that it would disrupt the status quo. But the cost of disruption now would actually be minimal, since the structure that currently exists is only a shell: most commercial HL waste is now contained in spent fuel cooling ponds adjacent to reactors.

There are more substantial disadvantages to be considered in the case of military HL waste. First, it might be objected that a new management authority should not be saddled with the existing inventory of mismanaged military waste. In rebuttal, it may be argued that existing military HL waste is the largest and most difficult problem, and the task of dealing with it cannot be shirked. Second, short-term treatment for military HL waste is quite different from that for commercial HL waste. Nevertheless, the long-term solutions and risks are similar. Third, if short-term military and commercial HL waste management operations are merged into the same authority, the public might blend short-term commercial and military practices in its perception of the overall radioactive waste problem. Although past AEC procedures for the temporary storage of military HL waste have been substandard, there is no reason to suppose that commercial as well as ERDA operations cannot achieve a substantially higher level of performance in the future.

A fourth argument against including short-term military and commercial HL waste operations within an integrated management structure is that to do so would jeopardize national security. Disclosure of detailed information regarding military waste composition, it is said, would reveal too much about our nuclear weapons program. But the evidence we have about military HL waste composition indicates that it is a heterogeneous and undecipherable conglomeration. (It may be that certain TRU waste, rather than the HL waste stream, could be revealing about weapons design and production.) Full disclosure of current military HL waste compositions might be harmful to the government -- but perhaps in large part because of the careless past waste management practices which it would reveal. Finally, even if there may be a valid security rationale for keeping waste composition classified, there is no reason why the waste management authority could not receive appropriate security clearance. The manufacture of nuclear warhead components and submarine reactor fuel is, in fact, contracted out to private industries.

A final possible drawback to including military HL waste operations in an integrated framework with commercial waste concerns international solutions to permanent disposition. Of course, no international authority would voluntarily assume responsibility for the U.S. military HL waste problem. However, an integrated waste management structure within the U.S., a structure that embraces commercial and military waste, would not preclude the U.S. waste management authority from participating in multinational joint ventures concerning commercial waste.

TRU Waste

If unified management of HL waste is desirable, should TRU waste also be included within the same management structure? With regard to permanent disposition, the same sort of reasoning applies to TRU waste as to HL waste. In the very long-term, the risks incurred in the management of HL waste and TRU waste tend to equalize, since the quantities of long-lived nuclides (especially plutonium) in these two streams are of the same order of magnitude. This indicates that a single management framework should be desirable. Somewhat different final disposition technologies may be used for TRU and HL waste, primarily because of their differing thermal qualities. But, in the future, permanent disposition of TRU waste is likely to be quite similar to that of HL waste.

The inclusion of short-term TRU waste management presents a more difficult question. Parallel economic and technological reasoning tends to show that short-term TRU commercial waste management would be handled more safely and efficiently in an integrated management system. Certain aspects of short-term TRU waste management differ substantially from HL waste operations. TRU waste requires different treatment (e.g., compaction or incineration). Also, the risks involved in the treatment, packaging, transportation, and temporary storage of TRU waste are somewhat less than for HL waste.

In addition, the inclusion of some military TRU waste poses a security problem. Unauthorized personnel must not discover the isotopic compositions of nuclear materials and shapes of components used in the weapons program. This may be a sufficient reason for excluding certain military TRU wastes from the system in the short-term. However, since inclusion of military TRU waste in the management

structure promises to yield safety and efficiency benefits, the burden ought to be on those arguing national security to show specifically why particular wastes should be excluded.

Waste Management and Reprocessing

Having considered the advantages and disadvantages of an integrated management structure for commercial and military waste, it is desirable to carry our discussion one step further back into the nuclear fuel cycle. We must briefly consider implications of the preceding analysis for the spent fuel reprocessing operation from which HL and some TRU waste emerges.

As previously discussed in chapter 3, reprocessing recovers plutonium and uranium for purposes of recycling it into light water reactors, into breeder reactors, or (in the military program) for use in nuclear weapons. It also happens that reprocessing generates HL and some TRU waste, but the waste is in forms which are far more suitable for permanent disposal than spent fuel prior to reprocessing. However, reprocessing and plutonium recycling give rise to certain radiological risks themselves. Although ERDA reprocesses spent fuel for military requirements, there are no commercial reprocessing plants now operating.

In these circumstances, the question arises: "Should ERDA and/or commercial reprocessing become part of an integrated waste management authority?" Two factors indicate that inclusion would be desirable.

First, reprocessing, temporary storage, treatment, packaging, transportation, and final disposition are all interdependent steps. Reprocessing and final disposition are arguably the most important

operations, all others being merely intermediate. The efficiencies of industrial integration, as argued above, might well justify the inclusion of reprocessing in a waste management structure.

The second factor transcends the issue of management efficiency. Radiological safety might indicate the recovery via reprocessing of as much plutonium and uranium as possible in order to reduce the long-term hazard. However, pushing the technology to the limit for safety reasons might well make reprocessing unprofitable as a private commercial enterprise. If reducing potential long-term radiological hazards is the paramount concern, either the government may absorb reprocessing operations into its functions, or it may subsidize private reprocessors to recover more plutonium and uranium from spent fuel than is justified from an economic viewpoint.

Nevertheless, the incorporation of ERDA and commercial reprocessing into an integrated waste management structure might not be politically feasible. The ERDA reprocessing operations upstream from HL waste relate intimately and sensitively to nuclear weapon requirements. Furthermore, the private sector may strongly resist government takeover of this step in the commercial nuclear fuel cycle which has so far been considered a private industry responsibility. If it is to be undertaken, the recovery and recycling of plutonium and uranium is an economic activity which should result in net benefits to society as a whole. Assuming there are benefits to be realized, the activity may be more efficiently conducted by private enterprise in a market economy. As a practical matter, however, in view of the large losses they have incurred thus far, private commercial reprocessors may welcome -- indeed they are actively seeking -- government subsidies in order to stay in the business.

On balance, it seems reasonable to conclude that waste management safety criteria may increase the costs of reprocessing to the point where this step in the commercial fuel cycle becomes unprofitable. If this occurs, government subsidy or take-over would seem preferable to relaxation of safety requirements and resulting increases in long-term radiological risks. On the other hand, the issue of the appropriate future role of the government in commercial reprocessing depends on many factors in addition to waste management. If it is deemed desirable to establish an integrated radioactive waste management system under government auspices, the launching of such an enterprise need not await resolution of that issue.

Alternative Management Forms

The most appropriate organizational scheme for post-fission radioactive waste management appears to be consolidated management of all waste streams under a single authority. But regardless of whether management is integrated or diversified, what possible forms could the manager or managers assume? Several alternatives should be considered.

Conceivably, the federal government's involvement in waste management might be reduced, rather than increased. This might entail handing over existing waste management responsibility to private industry (subject to regulation), to state governments, to an international authority, or to some combination thereof. If, however, the role of the federal government is to be expanded, three forms are possible: management by agency, by contract, or by corporation.

We can conceive two scenarios in which the federal government's role would shrink and waste management would become a responsibility of private industry, subject of course to government safety regulation. First, if management is unified, a private corporation as manager would be in a monopoly position. Therefore, government economic regulation, as well as radiological safety regulation, would be necessary in order to assure that prices charged for waste management services would bear a reasonable relationship to costs and that monopoly profits would not be realized. As an alternative scenario, waste management might be imagined as a competitive industry. However, there would be formidable obstacles to the growth and operation of competitive enterprise in this field. The initial capital investment for facilities would be high and involve considerable technological risk, perhaps too high and too risky for private industry to undertake without significant government subsidization. Decentralization of operations in a competitive market would prevent realization of economies of scale that would be possible within a unified management structure. Several firms might not be able to divide the waste disposal market profitably. Furthermore, as experience indicates, more than a handful of acceptable permanent waste repositories will be difficult to locate. Therefore, radioactive waste management could well be considered to be a "natural monopoly."

But the most important factor weighing against the development of a private competitive industry in the waste management business is economic. Competition tends to force private firms to sell their products at a price equal to the marginal cost of production, and over time the marginal cost of the lowest cost producer

tends to become the market price. Because of competitive pressure, private waste management firms would tend to generate significant external costs (especially of a long-term nature). Government involvement (in the form of taxation or direct regulation) is thus generally necessary to force industries to internalize such costs. Indeed, radioactive waste is itself a potential externality of the nuclear power business, and some form of government intervention in waste management is clearly necessary to prevent a socially undesirable amount of the potential externalities from being imposed on society as a whole.

Finally, a high degree of public trust in the waste management industry is required. While the public already tends to doubt the efficacy of government efforts in this area, public confidence may be an even greater problem for private waste management.

Another possible solution would be to turn the radioactive waste problem over to the state governments. A unified management structure would naturally preclude this option, since several state governments would be managers. But if one prefers decentralized management then this is a possibility, at least with regard to the various land-based disposal options. State management would probably be more responsive to the needs of local citizens. But it seems likely that states would rather not be burdened with the expense and responsibility. Many NRC Agreement States are now finding the financial strain and political turmoil associated merely with low-level waste regulation and surveillance too onerous.

Responsiveness to local needs may imply a flexibility of waste management strategies between states. This contradicts the

federal policy of uniformity as a means of assuring safety. State-by-state management would drastically alter the present federally dominated organization. Whereas today, federal preemptive power could compel states to accept national waste repositories (for example), in a state-managed situation, one state might well refuse to receive another's nuclear garbage without perhaps exorbitant compensation. On balance, therefore, state management does not seem to be advisable. This does not mean, however, that the states should have no influence on waste management operations within their borders.

A final means of reducing the federal government's role would be to give waste management responsibilities to an international agency. Although this may eventually be desirable, it is quite doubtful that it will occur in the near future. No international agency is likely to take on the responsibility for the U.S. radioactive waste problem, which is one of the most serious worldwide. However, international safety regulation, as distinguished from management, is feasible and necessary in certain circumstances. This matter is discussed further below.

The foregoing analysis indicates that it would probably be unacceptable to cut back the scope of the federal government's responsibility for waste management by transferring the task to the private sector, the states, or an international authority. The other broad option points toward a more unified, integrated management structure under federal government auspices.

The government might unify waste management in three possible ways -- by agency, by contract, or by corporation. In the long-term, about the same end may be reached using any of these means.

But the management forms chosen in the near future will have an important influence on the quality of future decision-making and the possibilities for further institutional evolution. Furthermore, the short-term economic and political benefits to be gained from an efficient and effective radioactive waste management organization are important.

Management by agency (ERDA) is the predominant form of the current framework. However, numerous activities are conducted by private industry pursuant to government contracts and under agency supervision, while others are the exclusive management responsibility of private firms, subject to government safety regulation. A primary objection to government agency operations regarding radioactive waste is their unbusinesslike character. The forces to which an agency such as ERDA is responsive are primarily political, not economic. This makes such an organization vulnerable to attacks. Indeed, political attack, or the threat of attack, is a most important stimulus or incentive for efficiency in many government agencies.

With regard to the military waste generated by reprocessing operations, ERDA as manager really has no "customer" to whom it is providing waste services. This means it can offer services which are more or less extensive, subject to the constraints of congressional appropriations and public opinion. Commercial reprocessors will be ERDA customers for waste management services. But in order to stay in the management business, ERDA would not need to charge commercial reprocessors the full cost of waste services provided. The balance may come from public appropriations. If, however, the reprocessor is forced to pay the full cost of waste management, that cost along with others incurred in reprocessing will eventually be reflected in the price for nuclear-electric service (as opposed

to higher taxes). Thus with management by government agency, the costs of commercial waste management services may be distributed to society either through the tax structure or the electric rate structure, or some combination of both.

Management by government contract is another possible mode. Here again, this approach is a large part of the existing setup. Management activities may be carried out by a variety of private contractors on a cost-plus basis, under more or less government supervision. Operations may be as tightly controlled as desired, simply by the terms of the contract. This option offers considerable flexibility in the selection of contractors so as to obtain the best available technical expertise in specialized areas. It has the further advantage of being a procedure which is familiar to both government and industry in the nuclear field. But management by contract does not escape the problems of direct government agency management since ultimate responsibility is still lodged in the agency.

The discussion above suggests, by a process of elimination, the establishment of an independent government corporation, charged with the responsibility for managing post-fission radioactive waste. The corporate form has its own advantages and drawbacks which must be weighed. There are also numerous precedents to draw upon, including numerous municipal waste management corporations at the local level, and the Atomic Space and Development Authority (ASDA) in New York which has taken over HL radioactive waste management from Nuclear Fuel Services in West Valley. At the federal level, there are also examples of federally-chartered public corporations, such as TVA, although we know of no existing federal corporation with primarily waste management functions.

Although its operations would be subject to safety regulation, a federal waste management corporation could be established as an independent, economically viable business. It would raise capital through the sale of bonds; it would charge users of its waste management services whatever was necessary to meet its costs, including a reasonable return on its investment. Thus, the corporation would be self-financing. It must also be recognized that such a corporation would be a self-regulating monopoly. It would have authority to set prices for its services without approval of an economic regulatory commission as would be required in the case of private investor-owned utilities. But the advantages and disadvantages in this regard are well understood and can be gleaned from experience with the large number of municipally-owned utilities in existence, as well as TVA.

A key factor would be the provision for a board of directors. The board should be composed so that it would not become a political dumping ground. The executive structure of the waste management corporation must have strong incentives for high quality effort. The corporation itself would have the option of contracting out those activities it believed could not be performed skillfully or economically "in-house."

As mentioned above, a federal corporation may be substantially more independent and immune to political pressure than a government agency. Such independence has advantages and disadvantages. A public corporation that is insulated from political pressure from the Executive Branch and Congress may also be unresponsive to public criticism. Here again the outcome is likely to depend on

the quality of appointees to the corporate board of directors and key executive positions.

In summary, the preceding analysis indicates that all HL and TRU waste streams should be managed under the auspices of a single authority, that expansion of the federal government's responsibilities is desirable, and, finally, that federal management via a public corporation appears to be the best available institutional mechanism for the task.

Waste Regulation

We have seen in chapter 4 that the existing regulatory framework for HL and TRU waste is fragmented between NRC and ERDA, with other agencies and certain states playing more or less important subsidiary roles.

Contraction of or withdrawal from safety regulation of radioactive waste operations seems impractical and unwise. Indeed, existing regulation is sparse and in need of future development.

This leaves us with two major questions. Is strong federal preemption of the field of radioactive waste regulation desirable? Is a strongly unified regulatory framework more workable than the current one?

Federal Preemption

The federal government now preempts virtually all regulation of HL and TRU waste from a radiological safety standpoint. Thus federal regulation largely displaces state regulation, whether the latter is more or less stringent. Notwithstanding arguments based on states' rights and sensitivity to local opinion, federal preemption

will probably continue to be necessary. Uniformity in waste management policy is highly desirable as long as the tendency is to level up, not down to some least common denominator. Nevertheless, overly stringent state regulation may unduly restrict the nuclear industry or the national security program. Because the adverse consequences of improper waste management might be so widespread, the radioactive waste problem has a national (and international) scope.

Federal preemptive authority will be required in the selection of sites for permanent waste repositories. The best available sites must be chosen and used. But no state is likely to welcome the idea of receiving the nation's radioactive waste within its borders. The only feasible way to eliminate these obstacles in our federal system is to repose paramount regulatory authority in the federal government, subject to advice from any state affected.

Integration of Regulatory Framework

Now we must consider whether the currently fragmented federal regulatory framework ought to be consolidated under a single authority. Integrated regulation is feasible even without unified management.

First, should commercial and military waste be regulated co-extensively? Although the actors involved in each case are different, the long-term nature of the problem is the same. (Short-term treatment of military and commercial HL waste could be significantly different, as noted previously.) In view of past experience, regulation of military waste may be necessary to insure that ERDA proceeds toward a solution to its very extensive military waste problem. Presently, there are no real regulatory incentives for ERDA to do so.

The safety of military waste operations is presently assured by regulatory authority that is divided between short-term ERDA self-regulation and long-term NRC independent regulation. Technically speaking, permanent disposition is deeply affected by earlier reprocessing, treatment, and packaging. It therefore makes little sense to divide regulatory responsibility along an artificial long-term/short-term line. Such a division invites regulatory conflicts and perhaps irrevocable mistakes. Regulation of short-term operations involving military waste may raise problems of dealing with classified information in some areas. But concern for the public health and safety may at least raise a presumption that national security does not justify exemption of a waste management activity from independent safety regulation.

Is co-extensive regulation of HL waste and TRU waste appropriate? Albeit less dangerous than HL waste in the short-term, TRU waste does require safety regulation. The question is merely who ought to be responsible for its regulation.

TRU waste emerges from more points in the various post-fission nuclear fuel cycle stages than HL waste. TRU waste comes from mixed oxide fuel fabrication and the head end of the reprocessing plant, as well as the back end. But the multiplicity of sources does not justify fragmented regulation. Moreover, the number of point sources involved in future industry operations should not itself be a major difficulty in regulation. As long as economies of scale in commercial reprocessing and fuel fabrication are realized, the number of facilities involved will remain quite manageable. Finally, unified regulation would eliminate NRC's current inability to exercise any authority

over military TRU waste regarding either short- or long-term facilities.

Regulation of Demonstration Projects

An issue which is currently a matter of contention is whether or not NRC should license ERDA's future waste repository demonstration projects. The Energy Reorganization Act of 1974 exempts ERDA research and development activities from NRC's authority. But there are several problems with such an exemption. First, a demonstration involves radiologically dangerous material. The risk involved in handling such material is accentuated by the novelty of the technology and methods used. Second, demonstration projects are likely, due to the costs incurred and operational momentum achieved, to be expanded into large-scale facilities. Safety reviews applied at some ill-defined time when a demonstration passes from an experimental to an operational stage may be quite unsatisfactory. Third, some important results of a waste repository demonstration will be inconclusive. The time allotted will be inadequate to meaningfully demonstrate all aspects of performance. But in the meantime, political, financial, and technological commitments will be made on the basis of the demonstration's presumed safety. Thus, demonstrations can and do have an effect on policy directions, regardless of their scientific validity.

The counterarguments in favor of exempting ERDA radioactive waste demonstrations from NRC licensing relate to the freedom and vitality of a research and development program. Research and development activities should not be unduly constrained. We must rely on research, development and small-scale demonstrations to find answers to some crucial, but as yet unsolved problems. Therefore, investigatory avenues should not be foreclosed, and some risks must be taken.

On balance, the exemption from licensing of major radioactive waste management demonstrations such as permanent waste repositories seems imprudent. However, somewhat relaxed safety criteria may be appropriate in licensing demonstrations.

Waste Research and Development

The final radioactive waste function to be considered is research and development. As of now, ERDA carries on most waste management r&d. It operates through contracts let to laboratories and firms throughout the country. NRC maintains a comparatively modest level of r&d activities, as does the private sector.

Is primary r&d responsibility properly reposed in ERDA or should it be shifted to another entity? A problem with the present system is that management and r&d functions as well as substantial regulatory authority are all found within ERDA. Differentiation of these three functions would serve to increase management incentives and, at the same time, help to assure that r&d efforts are objective.

An effective r&d effort is vital to the success of both management and regulation in the long term. In separating management from r&d, there is a risk that r&d will be pursued increasingly for its own sake, rather than as a process for improvement of operations. On the other hand, keeping management and r&d under the same roof (ERDA) may mean either that aggressive management of a current problem is hampered by the prospect of a better solution always on the r&d horizon, or, alternatively, that promising research avenues are foreclosed too early by the overwhelming pressure of demonstrations which can lead to premature applications. Moreover, separating waste management from waste r&d means that ERDA r&d in this field can also be more responsive to the requirements of an independent regulatory agency, NRC.

Assuming a rather clear separation of management, regulation and r&d is, on balance, desirable, the concerns expressed above can be dealt with in determining an appropriate institutional relationship between ERDA, NRC, a federal waste management authority, and the private sector of nuclear industry in addressing two issues: the establishment of radioactive waste r&d priorities; and the development of a mechanism to assure rapid and effective application of promising results of ERDA r&d programs in this field. These issues, summed up in the word "commercialization," are complex and pervade ERDA's primary mission as provider of energy technology to the nation as a whole.

* * *

An important issue reserved for the end of this chapter is whether or not the regulator, NRC, should actively participate in the selection of technological options to be implemented in waste management activities. Some would contend that a regulator needs to exercise this function in order to promulgate meaningful rules. But a passive role for the regulator is more appropriate for the independent, adjudicatory nature of the licensing function. The regulator's duty is to set levels of performance to be attained in waste management. The manager then has the incentive to devise the most cost-effective means for reaching these criteria. The regulator must then approve or disapprove proposals for operations.

Chapter 6

RECOMMENDATIONS

Post-fission radioactive waste is highly toxic for extremely long periods of time--at least thousands, perhaps hundreds of thousands, or even a million years. Large quantities of HL waste are being temporarily and imperfectly stored in tanks at plutonium production facilities, and large amounts of spent fuel are being discharged periodically from commercial power reactors into increasingly crowded storage pools.

Whether optimists or pessimists, as we look to the future, we share an expectation that national security and energy supply, and the complex of institutions supporting those vital imperatives, will surely result in the creation of rapidly growing volumes of radioactive waste in the United States. There is an understandable tendency to shrink from this grim reality. An optimist may deny there is a serious problem because time and money will provide technology for a variety of solutions. A pessimist may deny there is a solution because--sometime, somewhere--man-made or natural cataclysms will inevitably breach any technological containment, and toxic radioactive waste will then spill or seep into the biosphere.

The morality of the U.S. predicament is arguable. Our survival as a nation seems to rest heavily on our nuclear arsenal, and the survival and well-being of our own and other societies depend on adequate energy. But is it moral to produce any toxic material with a half-life of 24,000 years? And is it right to continue activities which generate radioactive waste when a safe method for permanent disposal has not been fully demonstrated?

When viewed in such apocalyptic terms, the radioactive waste problem tends to befuddle the mind, polarize the public, and stalemate the government. But if we view the problem not as one that must be solved once and for all, but rather as one (among many) that must be dealt with now and for the foreseeable future, a number of steps can be taken immediately to strengthen substantially our capacity to manage radioactive waste now and in the future.

The following specific recommendations concerning policy goals, organization, and implementation emerge from and are supported by the preceding chapters of this report. It is noteworthy that most of them are not especially sensitive to future scientific revelations, technological developments, or changes in attitudes within society. While some of the recommendations may appear to be quite far-reaching -- especially those regarding a new structure for radioactive waste management -- it is important to recall that they can be implemented in most instances with little, if any, impact--welcome or resisted--upon large vested interests. There is today no long-term management of radioactive waste, no comprehensive scheme for regulation of such waste, and no commercial reprocessing industry.

Thus we have an opportunity -- perhaps our last clear chance -- for institutional development.

Policy Goals

1. The technological criteria for U.S. radioactive waste policy should be clarified and the applicability of such criteria to various categories of waste should be established.

The overall technological criteria should be containment and isolation from the biosphere of all post-fission radioactive waste. These criteria would be applicable to all phases of

radioactive waste management, including temporary storage, treatment, and transport, as well as permanent disposition. The application of such criteria to permanent disposition would mean that radioactive waste would be completely contained and fully isolated from the biosphere for sufficient time to provide reasonable assurance that no significant increase in natural background radiation levels (local or general) will result if and when release occurs.

The criteria of containment and isolation would be generally applicable to commercial waste, whether or not commercial reprocessing is introduced, and to military waste. The criteria would be rigorously applied to all HL waste, existing and future. They would also be applied presumptively to all future TRU waste, so that the safety of less stringent criteria must be demonstrated before they are adopted. A separate study should be made to provide a basis for determining the extent to which these criteria would be retroactively applied to existing TRU waste.

2. Institutional criteria for U.S. radioactive waste policy should be developed and adopted.

One important institutional criterion would be the existence of strong incentives for safe management of radioactive waste. Institutional arrangements should generate strong incentives for the organizations and persons involved to play their respective roles--whether in waste management operations, safety regulation, or research and development--with intelligence and dedication. To the maximum extent possible, the incentive for safe management should be derived from within the organization having operational responsibility, rather than be imposed from outside by government regulation or public criticism.

A second criterion would be institutional stability. This requires differentiation of the radioactive waste problem into functional tasks or areas of responsibility, and development of a system of checks and balances that will govern relations among those charged with different areas of responsibility. The radioactive waste problem should be differentiated into management, regulation, and research and development. Primary responsibility for each functional task should be assigned to a different organization. The Congress would prescribe and adjust relations between managers, regulators, and technology developers.

Institutional stability also requires sufficient jurisdiction to perform all the interdependent components of an assigned functional task. Inadequate scope or jurisdiction will prevent effective overall performance.

A third institutional criterion would be adaptability. Whatever the initial institutional arrangements may be, they should be capable of responding to rapid expansion in the dimensions and to changes in the character of the radioactive waste problem. Radioactive waste institutions should also be capable of adapting to profound changes in the social and political environment in which the problem is embedded.

3. As part of developing policy for the long-term disposition of radioactive waste, the choice between permanent disposal and perpetual care should be fully assessed and debated. Current policy favors permanent geologic disposal with some reasonable possibility for short-term reversibility. An alternative policy would be reliance on technological systems requiring virtually perpetual surveillance

and some degree of active management. The safety of reliance on human care rests on a prediction that the stock of knowledge concerning nuclear matters will continue to develop and accumulate and never be substantially lost throughout the future turbulent course of human history.

Permanent geologic disposal involves present commitments based on present knowledge and predictions of the geologic history of particular formations hundreds of thousands of years into the future. Once made, geologic dispositions will be extremely difficult, if not impossible, for future generations to reverse if we guess wrong. Permanent geologic disposal thus relinquishes to nature the future management of radioactive waste.

Perpetual human care involves commitments that future generations can modify, including a basic shift from continued surveillance to permanent geologic disposal. As long as technological containment systems function safely, surveillance alone is required. However, there is no technological artifact in existence today, or that can reasonably be expected to appear in the future, that is capable of performing its originally intended function for hundreds of thousands of years. Deterioration in performance is unavoidable. Therefore, perpetual human care entails periodic renewal and replacement of waste containment systems in addition to the surveillance that will always be necessary. Perpetual care retains for man the waste management burden and imposes that burden on successive generations.

Technological systems, which maintain retrievability, and geologic disposal methods, which do not, may both be vulnerable to

natural catastrophes. However, technological systems may be more vulnerable than geologic disposal to man-made calamities.

The motives which underlie a policy which favors permanent disposal of radioactive wastes are ambiguous indeed--confidence in our present mastery of nature, fear of future social collapse, or an expedient desire to elicit public acceptance of nuclear power development. Similarly, the motives underlying a policy favoring surveillance are difficult to discern--faith in the capacity of man to muddle through, fear of future natural disasters, or an expedient desire to do the minimum necessary to accelerate nuclear development. .

Organization

4. A national Radioactive Waste Authority should be established as a federally chartered public corporation. The Authority would manage all HL and TRU wastes under U.S. jurisdiction or control.

The Authority would be independent of ERDA. It would be governed by a board of directors composed of members drawn from government, nuclear industry, the academic research community, and the general public.

The Authority would own all HL and TRU waste facilities, including facilities for temporary storage, treatment and permanent disposition of waste, and any specially constructed waste transport containers. It would take over existing commercial and military waste facilities. If commercial reprocessing is not authorized, the Authority would construct and manage central storage facilities for commercial spent fuel.

The Authority would be self-financing. It would issue bonds and recover the full costs by appropriate charges for waste management

services to be paid by those receiving such services. It would be authorized to conduct waste management operations itself or to contract with private industry for the conduct of such operations.

The Radioactive Waste Authority would thus be intended to provide comprehensive, integrated, efficient management of both commercial and military HL and TRU wastes.

5. With NRC as the primary agency, a comprehensive regulatory framework should be established to assure the safety of all radioactive waste management operations under U.S. jurisdiction or control. A unified regulatory framework is necessary whether or not the national Radioactive Waste Authority recommended above is established. The regulatory framework would be specified by federal law that would preempt all other regulation.

All radioactive waste management operations involving HL or TRU waste, including both commercial and military waste at existing and future facilities, would be subject to the same regulatory scheme. Of course, different kinds of waste from different programs would be regulated differently when circumstances warranted, but all regulation would occur within a single framework.

NRC would have authority to promulgate specific standards for all licenses, to license sites, to license the construction and operation of fixed facilities, to monitor all waste management activities, and to order appropriate corrective and enforcement measures. NRC would also have authority to license waste management demonstration projects, except for small pilot projects. DOT and NRC would have concurrent authority over all radioactive waste transport operations subject to U.S. jurisdiction or control.

Within the NRC-headed regulatory framework other interested federal agencies such as ERDA, EPA, and CEQ, affected state governments, and interested international agencies would have advisory roles in major waste management licensing actions. EPA would continue to have authority to develop generally applicable radiation protection standards which would guide NRC development of standards for radioactive waste licenses. Any waste storage or disposal option proposed to be implemented beyond U.S. national jurisdiction would be subject to concurrent U.S. regulatory jurisdiction and approval by the international commission described in recommendation 7.

6. ERDA should continue to have primary government responsibility to conduct and sponsor research and development of radioactive waste management technologies. ERDA would plan research and development priorities and programs in consultation with NRC, EPA, the U.S. nuclear industry, the proposed national Radioactive Waste Authority, and interested international agencies.

7. The U.S. government should propose that an international Radioactive Waste Commission be established under the IAEA.

Prior approval of the IAEA commission would be required for any storage or disposal operation which would result in the dispersal or emplacement of radioactive waste beyond national jurisdiction. This would include seabed, ice sheet and outer space disposal of HL waste and ocean dumping of TRU waste. Prior consultation with the IAEA commission would be required before each national licensing action authorizing a permanent waste disposition under exclusive national jurisdiction.

Implementation

Recommendations concerning specific waste management strategies and permanent disposition options are beyond the scope of this report. A recommendation is developed, however, with respect to the decisional process.

8. The pending NRC decisional process concerning commercial reprocessing and widescale use of mixed oxide fuel should be expanded to include the issues of radioactive waste partitioning, HL waste management, and spent fuel management in the event of no reprocessing.

The NRC decision is currently focused on the economic, environmental, health and safety, and safeguards issues arising out of commercial reprocessing, and plutonium-bearing fuel fabrication and recycling in light water reactors. Equivalent attention should be given to radioactive waste management issues. A decision to permit reprocessing includes irreversible commitments concerning the composition and future management of radioactive wastes. Since the schedule for NRC's reprocessing decisional process is slipping, it should be possible to include full discussion of commercial radioactive waste management issues based on ERDA's forthcoming environmental impact statement without undue additional delay. Indeed, failure to include radioactive waste management issues based on the fullest practicable weighing of risks, costs and benefits may make the NRC's decisional process vulnerable to legal attack for failure to comply with NEPA.

GLOSSARY

actinide series: The series of elements beginning with actinium, element No. 89, and continuing through lawrencium, element No. 103, which together occupy one position in the periodic table. The series includes uranium, element No. 92, and all the man-made transuranium elements. The group is also referred to as the "actinides."

cladding waste: Fuel rods in most nuclear reactors today are made up of fissionable materials clad in a protective alloy sheathing which is relatively resistant to radiation and the physical and chemical conditions that prevail in a reactor core. The spent fuel rods, after removal from the reactor and storage to permit radioactive decay of the short-lived fission products, are removed and in certain fuel cycle systems, are chopped up, and the residues of the fissionable materials are leached out chemically. The remaining residues, principally the now radioactivated cladding material (zirconium alloys, etc.) and insoluble residues of nuclear fuel, fission products, and transuranium nuclides, are left behind as cladding waste, which is a special category of transuranium radioactive waste.

critical: The condition in which a material is undergoing nuclear fission at a self-sustaining rate; the critical mass of a material is the amount that will self-sustain nuclear fission when placed in an optimum arrangement in its present form; the minimum critical mass is the amount of a fissile isotope that will self-sustain nuclear fission when placed in optimum conditions.

curie (Ci): A unit of radioactivity defined as the amount of a radioactive material that has an activity of 3.7×10^{10} disintegrations per second (d/s); millicurie (mCi) = 10^{-3} curie; microcurie (uCi) = 10^{-6} ; nanocurie (nCi) = 10^{-9} ; picocurie (pCi) = 10^{-12} curie; femtocurie (fCi) = 10^{-15} curie.

decommissioning: The process of removing a facility or area from operation and decontaminating and/or disposing of it or placing it in a condition of standby with appropriate controls and safeguards.

disposal: The planned release or placement of waste in a manner that precludes recovery.

engineered storage: The storage of radioactive wastes, usually within suitable sealed containers, in any of a variety of structures especially designed to protect them from water and weather, and to help keep them from leakage to the biosphere by accident or sabotage. They may also provide for extracting heat of radioactive decay from the waste.

fertile material: A material, not itself fissionable by thermal neutrons, which can be converted into a fissile material by irradiation in a reactor. There are two basic fertile materials, uranium-238 and thorium-232. When these fertile materials capture neutrons, they are partially converted into fissile plutonium-239 and uranium-233, respectively.

fissile material: While sometimes used as a synonym for fissionable material, this term has also acquired a more restricted meaning, namely, any material fissionable by neutrons of all energies, including (and especially) thermal (slow) neutrons

as well as fast neutrons; for example, uranium-235 and plutonium-239.

fission: The splitting of a heavy nucleus into two approximately equal parts (which are nuclei of lighter elements), accompanied by the release of a relatively large amount of energy and generally one or more neutrons. Fission can occur spontaneously, but usually is caused by nuclear absorption of gamma rays, neutrons or other particles.

fissionable material: Commonly used as a synonym for fissile material. The meaning of this term also has been extended to include material that can be fissioned by fast neutrons only, such as uranium-238. Used in reactor operations to mean fuel.

fission products: The nuclei (fission fragments) formed by the fission of heavy elements, plus the nuclides formed by the fission fragments' radioactive decay.

fuel (nuclear, reactor): Fissionable material used as the source of power when placed in a critical arrangement in a nuclear reactor.

fuel cycle: The complete series of steps involved in supplying fuel for nuclear power reactors. It includes mining, refining, the original fabrication of fuel elements, their use in a reactor, chemical processing to recover the fissionable material remaining in the spent fuel, re-enrichment of the fuel material, and refabrication into new fuel elements, transportation of materials between these various stages, and management of radioactive waste.

fuel reprocessing: Processing of irradiated (spent) nuclear reactor fuel to recover useful materials as separate products, usually separation into plutonium, uranium, and fission products.

half-life: The time in which half the atoms of a particular radioactive substance disintegrate to another nuclear form. Measured half-lives vary from millionths of a second to billions of years. After a period of time equal to 10 half-lives, the radioactivity of a radionuclide has decreased to 0.1 percent of its original level.

high-level liquid waste: The aqueous waste resulting from the operation of the first-cycle extraction system, or equivalent concentrated wastes from subsequent extraction cycles, or equivalent wastes from a process not using solvent extraction, in a facility for processing irradiated reactor fuels. This is the legal definition used by ERDA; another definition used at the ERDA Hanford Reservation for its waste, is: fluid materials, disposed of by storage in underground tanks which are contaminated by greater than 100 microcuries/milliliter of mixed fission products or more than 2 microcuries/milliliter of cesium-137, strontium-90, or long-lived alpha emitters.

ionizing radiation: Any radiation displacing electrons from atoms or molecules, thereby producing ions. Examples: alpha, beta, gamma radiation, short-wave ultraviolet light. Ionizing radiation may produce severe skin or tissue damage.

isotope: One of two or more atoms with the same atomic number (the same chemical element) but with different atomic weights. An equivalent statement is that the nuclei of isotopes have the

same number of protons but different numbers of neutrons.

Isotopes usually have very nearly the same chemical properties, but somewhat different physical properties.

long-lived isotope: A radioactive nuclide which decays at such a slow rate that a quantity of it will exist for an extended period; usually radionuclides whose half-life is greater than 3 years.

nuclide: A species of atom having a specific mass, atomic number, and nuclear energy state. These factors determine the other properties of the element, including its radioactivity.

partitioning: The process of separating liquid waste into two or more fractions. In this report, partitioning is used specifically with reference to the removal of certain radioisotopes from the waste in order to facilitate subsequent waste storage and disposal. "Isotope mining" is used to describe the fractionation of waste when radioisotopes are extracted and used in other applications.

plutonium: A heavy, radioactive, man-made, metallic element with atomic number 94. Its most important isotope is fissionable plutonium-239, produced by neutron irradiation of uranium-238. It is used for reactor fuel and in weapons.

rad (Acronym for radiation absorbed dose): The basic unit of absorbed dose of ionizing radiation. A dose of one rad means the absorption of 100 ergs of radiation energy per gram of absorbing material.

radiation: The emission and propagation of energy through matter or space by means of electromagnetic disturbances, which display

both wave-like and particle-like behavior; in this context the "particles" are known as photons. Also, the energy so propagated. The term has been extended to include streams of fast-moving particles (alpha and beta particles, free neutrons, cosmic radiation, etc.). Nuclear radiation is that emitted from atomic nuclei in various nuclear reactions, including alpha, beta, and gamma radiation and neutrons.

radioactive contamination: Deposition of radioactive material in any place where it may harm persons, spoil experiments, or make products or equipment unsuitable or unsafe for some specific use. The presence of unwanted radioactive matter. Also radioactive material found on the walls of vessels in used-fuel processing plants, or radioactive material that has leaked into a reactor coolant. Often referred to only as contamination.

radioactivity: The spontaneous decay or disintegration of an unstable atomic nucleus, usually accompanied by the emission of ionizing radiation. Activity is a measure of the rate at which a material is emitting nuclear radiations, and is usually given in terms of the number of nuclear disintegrations occurring in a given quantity of material over a unit of time. The standard unit of activity is the curie (Ci), which is equal to 3.7×10^{10} disintegrations per second. The words "activity" and "radioactivity" are often used interchangeably.

radioisotope: A radioactive isotope. An unstable isotope of an element that decays or disintegrates spontaneously, emitting radiation. More than 1300 natural and artificial radioisotopes have been identified.

rem: A unit of measure for the dose of ionizing radiation that gives the same biological effect as one roentgen of x rays; one rem equals approximately one rad for X, gamma, or beta radiation.

roentgen (abbreviation r): A unit of exposure to ionizing radiation.

It is that amount of gamma or X rays required to produce ions carrying 1 electrostatic unit of electrical charge (either positive or negative) in 1 cubic centimeter of dry air under standard conditions. Named after Wilhelm Roentgen, German scientist who discovered X rays in 1895.

special nuclear material (SNM): Plutonium, uranium-233, uranium-235, or uranium enriched to a higher percentage than normal of the 233 or 235 isotopes.

transuranics: Nuclides having an atomic number greater than that of uranium (i.e., greater than 92). The principal transuranium radionuclides of concern in radioactive waste management are tabulated below with their half-lives:

<u>Nuclide</u>	<u>Half-Life (Years)</u>	<u>Principal Decay Modes</u>
Neptunium-237	2,140,000	alpha
Plutonium-238	86	alpha, spontaneous fission
-239	24,390	alpha, spontaneous fission
-240	6,580	alpha, spontaneous fission
-242	379,000	alpha
Americium-241	458	alpha
-243	7,950	alpha
Curium -245	9,300	alpha
-246	5,500	alpha, spontaneous fission

The transuranium nuclide produced in largest amounts is Pu-239; Am-241 is also produced in significant amounts.

transuranic (TRU) waste: Any waste material measured or assumed to contain more than a specified concentration of transuranic elements. This is the definition used by ERDA. The specified concentration is currently set at 10 nanocuries of alpha emitters per gram of waste. (The Nuclear Regulatory Commission (NRC) has not yet adopted a regulatory definition of transuranic waste.) The 10 nanocurie/gm standard is under scrutiny and may be revised upward.

uranium: A radioactive element with the atomic number 92 and, as found in natural ores, an average atomic weight of approximately 238. The two principal natural isotopes are uranium-235 (0.7% of natural uranium), which is fissionable, and uranium-238 (99.3% of natural uranium), which is fertile. Natural uranium also includes a minute amount of uranium-234. Uranium is the basic raw material of nuclear energy.

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BEFORE THE UNITED STATES NUCLEAR REGULATORY COMMISSION

In the matter of	)	
	)	
Required Atomic Energy Act	)	
Safety Determination Regarding	)	NRC Docket No. _____ -
Disposal of High-Level Radio-	)	
active Wastes	)	
	)	
	)	

PETITION OF THE
 NATURAL RESOURCES DEFENSE COUNCIL
 FOR A DETERMINATION, PRIOR TO
 ISSUANCE OF REACTOR OPERATING
 LICENSES, WHETHER RADIOACTIVE
 WASTES CAN BE DISPOSED OF SAFELY

EXHIBIT D

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EXHIBIT D

"Partitioning of Nuclear Wastes; How, Why, and When",
M.J. Steindler, from Proceedings of Nuclear Regulatory
Commission Workshop on The Management of Radioactive
Waste: Waste Partitioning as an Alternative, pp. 380-
395 (June 8-10, 1976).

Proceedings of Nuclear Regulatory Commission Workshop on

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Office of Nuclear
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PARTITIONING OF NUCLEAR WASTES; HOW, WHY, AND WHEN

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INTRODUCTION

This workshop has been assembled by the Nuclear Regulatory Commission to provide views on partitioning that may aid the newly established Waste Management Branch in decisions dealing with criteria for waste management. It should be our intent, therefore, to provide an exposition of alternatives and rationales related to partitioning that can be used to determine the course of actions required for licensing. In order to do this effectively, I would first like to call attention to the scope of the partitioning process, since this term has been one of the most abused in the nuclear vocabulary.

The partitioning process is usually defined as the separation of nuclear wastes into an actinide fraction and a second fraction containing all other radionuclides. Further, the separation is commonly applied to the high-level waste because that stream contains most of the fission products. The objective of partitioning, however, is to reduce the time for which confinement of at least the major part of the radioactive waste must be assured. Therefore, the partitioning process must have a broader scope in order to include isolation of long-lived fission products such as iodine 129 and technetium 99 and long-lived activation products such as carbon 14. Further, the actinide content of wastes not extensively contaminated by fission products may well exceed that of

high-level waste, and therefore such streams should be included for treatment to separate long-lived radionuclides. The disposition of the collected long-lived radionuclides, including the actinides, is also an important adjunct to the rationale for the objective of the partitioning process. Hence, the steps required for the preparation of the long-lived fraction for subsequent transmutation, extraterrestrial elimination, or other disposal modes become part of the partitioning process. Consequently, reference to the scope of the partitioning process includes the broad range of separation processes applied to all types of nuclear wastes; the handling, fabrication, and recycle of actinides and other nuclides subjected to transmutation; and the elimination of packaged waste by extraterrestrial transport. Finally, the short-lived radionuclide fraction obtained by partitioning is to be stored for a modest period such as a few thousand years, but storage is not usually considered to be an integral part of the partitioning process.

RATIONALE FOR PAST ACTIONS

Waste disposal presents a set of unique circumstances to the licensing agencies that can best be illustrated by comparison with other fuel cycle processes. In my opinion there are no major technical reasons why the handling of nuclear wastes cannot be done as safely as most other operations in the nuclear business. However, there is no such convincing evidence regarding the final disposal of wastes. Further, during the licensing of fuel cycle facilities such as reprocessing and fabrication plants, review of place and process features are based on reasonably clear experimental data or verifiable models. Such bases for

critical reviews tend to assure the safety of the operations involved. Waste disposal, on the other hand, is in this respect quite different from the other parts of the fuel cycle, and long-term waste disposal poses qualitatively and quantitatively different problems both in the regulatory domain and in the eyes of the public. Finally, the principles employed in the licensing process for nuclear facilities are moderately well developed, have been accepted by the public, and deal with modest-term, operational safety. The corresponding principles for waste disposal facilities have not been developed, have not reached public acceptance, and deal for the first time with very long-term, passive maintenance of barriers.

We have become used to a very high degree of redundancy and reliability in nuclear safety matters. Design of this reliability is often based on exhaustive experimentation. We have become used to the application of such criteria in both the licensing and the operation of nuclear facilities, and we have even had to apply much of this redundancy to maintain the safety of the public. The lack of serious accidents in the nuclear industry demonstrates the effectiveness of this level of concern. Nevertheless, the excellent record of the industry and the care taken in licensing actions has not been enough to quiet the rumbles of the critics.

Now consider the long-term disposal of nuclear waste. The assurances used for the disposal of waste in geologic formations or elsewhere rest largely on geologic predictions and inferential evidence. There is not now, to the best of my knowledge, a significant program on predictive

geology being supported by ERDA or the USGS. I also understand that most geology departments in universities are not active in this field. It is not clear that any organization is currently pursuing a sufficiently thorough study of this particular field to furnish, in the foreseeable future, the kind of predictive data that we have been used to in other fields, for example chemical safety of reprocessing plant operations. I recognize that it is quite easy to generate reliable, predictive data based on the normal laws of chemistry and physics, particularly if we understand the mechanics of the phenomena. I also recognize that it is much more difficult to obtain the same kind of analyses in the area of geology. We generally do not understand the laws governing fundamental geological processes, we have only poor ideas about mechanisms and incomplete knowledge of structures, and therefore we have difficulty in providing reliable predictions. Especially important is the present inability to test the validity of models of geologic behavior.

This generally inadequate state of scientific information about the environment of the waste in the depositories is perhaps the major factor contributing to our inability to provide licensing reviews that will assure that the safety of the public will be protected. The perceived risk of gross errors increases rapidly with the length of the time-scale of the prediction.

Another part of the reliability problem for long-term predictions is worth mentioning. There is now no firm decision on the form of high-level waste to be assigned to the disposal site, though considerable effort has been expended to develop inert matrices for the waste. Some

of the methodology that seeks to assure, by calculation, that the emplacement of waste is safe is dependent on the prediction of the very long-term behavior of materials in only mildly aggressive environments. Here too the state of knowledge is inadequate to provide the level of reliability that has thus far been employed. These two aspects of the safety analysis problem are adequate to illustrate the effect of extending time scales to 10^5 or more years.

Because of these difficulties, licensing actions on waste disposal are likely to take on a radically different tone. When required to provide expert opinions on geologic phenomena in the long time frame required, few if any reputable geologists are likely to insist that a particular depository selected by ERDA or industry will remain stable. Further, materials scientists may encounter the same difficulties when discussing very long-term leach rates, transport properties, or other phenomena important to safety issues. Finally, the experimental bases for conclusions drawn about the interaction of waste and environment will be essentially absent. Under these conditions, the licensing agencies will have to proceed on bases with which neither the public nor the agencies are particularly satisfied or familiar. Specifically, most evidence used to evaluate the safety issues will be based on extreme extrapolations of uncertain information, little of which will be subject to test. The normal, strongly redundant approaches which the public has come to expect from the nuclear industry will be absent.

POTENTIAL IMPACT OF PARTITIONING

The technical issues of partitioning aside, the potential impact of partitioning on the licensing process seems reasonably clear. Reduction of time scales from a million years to, for example, a thousand years is not just three orders of magnitude. This reduction would allow a considerable increase in the reliability of estimates of geologic stability and materials behavior. While it would be naive to assume that all of the uncertainties that attend the predictions would be eliminated when the time scale is reduced, it seems reasonable to assume that the licensing process for depositories that are required to be functional for short periods could approach the rigor presently encountered in some of the more complex, but apparently acceptable, reactor safety questions. In short, ensuring the integrity of waste in a disposal site for a thousand years appears feasible; the same requirement extended to a million years appears at this time to be incredible.

The consequences of these differences can be profound. An industry already under attack for alleged laxity in the public safety domain can, in my opinion, ill afford to reduce the credibility of its safety posture. The inevitable reduction that would attend the licensing of waste repositories under present conditions may intensify the opposition to the point that nuclear power generation would be in jeopardy.

OTHER CONSIDERATIONS

We have addressed to some extent the "why" of partitioning. Of the other two questions, the "when" seems to depend more on economic

factors than on safety. Liquid storage of wastes for 30-50 years can, I believe, be made adequately safe and reliable. Solids of any type can be stored for similar periods under high-integrity conditions. The timing for partitioning, therefore, could be selected at leisure as long as solidification processes do not make subsequent treatment impractical. The glass form of high-level waste shows a distinct disadvantage in this regard.

The "how" of partitioning is again under study by ERDA, and there is no doubt that the details of a feasible technology will be developed in a few years. I favor an integrated waste management scheme carried out at a waste management plant that may look a great deal like a reprocessing plant but is able to handle all waste streams from nuclear power production operations. The products of this plant are a long-lived waste, packaged for burning or elimination; a nonnuclear waste stream, to be treated by conventional means or discharged directly to the environment; and the short-lived waste, packaged for transport and subsequent disposal in geologic formation.

CONCLUSIONS

In conclusion, the present ignorance of safety-related issues of very long-term geologic storage results in the weakening of traditional assurances employed in the licensing of such facilities. Such actions appear likely to endanger the public acceptance of nuclear power. Partitioning and consequent reduction in time scales for storage of wastes can remedy this difficulty to a large extent. It appears reasonable, therefore, to develop the technology of partitioning and to

integrate waste management into a single system. There appears to be no urgent, safety-related need to provide for final disposal of wastes very soon after their formation.

Conclusions specifically related to the NRC position are as follows:

1. The NRC should not take specific actions at this time related to partitioning except to direct policy toward provisions that maintain ready retrievability of waste containing long-lived components and toward provisions that do not preclude subsequent partitioning of retrieved waste.
2. The NRC should initiate efforts to determine if relaxation of the intense safety posture in nuclear affairs, when applied to long-term waste disposal, will result in unacceptably strong opposition to nuclear power generation.
3. The NRC should encourage the development of scientific information related to geologic disposal and materials behavior to ensure that the reliability of analyses for short-term disposal repositories is adequate to ensure public acceptance.

DISCUSSION OF M. J. STEINDLER'S PRESENTATION

Q. (B. L. Cohen): Why should we be worrying about the long-term security of waste that is buried far under the ground, when the mill tailings are obviously many orders of magnitude more dangerous than the buried waste will be after a thousand years? Also, can you guarantee that our burning up all of the gas, oil, and coal in the world won't be doing a lot of harm to people living 10,000 to 100,000 years from now? And what about all the sulfur that we're putting into the biosphere? In fact, with respect to our agricultural practices, the population explosion, or any aspect of human endeavor, there are no standards as stringent as those that you want from the nuclear industry.

A. The point that I'm making is that the kind of requirements for redundancy and safety that typify our present licensing arrangement--the requirements, in other words, with which the public has gradually become reasonably satisfied--are so stringent that we can't possibly apply them to waste management. I haven't said anything about any of the other things that go on in society because I'm not addressing the whole world and I'm not trying to solve the problems of the whole world. I think it's illegitimate to claim that we can ignore one poison because we've got a worse one somewhere else.

Now there are two assumptions that I'm making:

1. Technically competent people can agree that the perceived risk is different for a thousand-year time period than for a million-year time period.
2. If you choose to address the question of licensing in a different way from that used in the past, the public will not like it and may drive you out of the business.

I'm suggesting, then, that the current licensing process is extremely rigorous, and that if we attempt to maintain the same type of standard for waste disposal, we will have a problem. Now, one way to solve the problem would be to partition the wastes; this would solve a portion of the time scale problem and reduce some of the technical reliability problems, as well.

Q. (B. L. Cohen): What about the mill tailings?

A. The licensing people will tell you that that's not in their domain. This is a legitimate question, though, in the sense that it represents a very large waste. However, I do not propose to suggest that we partition mill tailings.

Q. (R. E. Isaacson): Do you think the laws of thermodynamics are going to change in the next million years?

A. There has to be something behind that question.

- Q. (R. E. Isaacson): It's your perception that we can't predict what will happen in that time span. I believe, however, that we can put waste in any form that is thermodynamically stable with the certainty that there will be no interaction or reaction for the next million years.
- A. Thermodynamics is a process of equilibrium. The problems that we are addressing here, however, are largely kinetic. The reason you can't find out what's going on in the stress curves in the stainless steel under a mild environment is not that you don't understand the thermodynamics involved, but that you don't know either the rates at which some of these processes go on or anything about the mechanisms of these processes. So I agree with you: if we were smart enough to understand the system, we could have reasonable faith in extrapolation. Our problem, however, is that we don't understand the rates because we have no idea of what the mechanisms are.
- Q. (R. Chollister): You advocated that high-level wastes be stored in a readily retrievable form, presumably as a liquid. Where would you store this liquid?
- A. I didn't specify a liquid form. I said that you can store it in a tank if you want to; however, it can be in solid form and still be retrievable. In fact, if you want fairly long-term retrievability, I would suggest that you insist on solids.

Q. (G. Graves): I don't necessarily agree with your implication that the rules for reactors and waste disposal should be the same. A reactor is a dynamic situation with a lot of stored energy in it, and if things were to go wrong you would have a reasonably definable set of consequences. Waste disposal, on the other hand, is a passive situation. There are various barriers--the glass, the can, the geologic formation; and there is evidence of geologic stability over thousands of millions of years. You also have to consider economic factors: any additional waste-processing costs will be passed on to the consumer in the form of higher electric power costs.

A. The ground rules I'm talking about are not the specific provisions for safety, but rather the safety criteria in general that are applied to nuclear facilities. At the moment, those redundancy requirements are very stiff; and what I'm saying is that, if similar requirements are applied to waste processing, they will cause problems. I'm not saying that they should be applied. In the area of reprocessing, in fact, a good case could be made for the position that present safety and redundancy requirements are too high. But if, after stressing redundancy to the public for so long, we suddenly shift to a nonredundant safety analysis for a particular portion of the cycle, we will have to be able to justify this to the public.

Q. (W. Nechodom): I suggest that a highly stable form of waste, backed up by a very high-integrity canister, backed up by a

stable geologic formation, and then backed up by Bernie Cohen's analysis, is surely redundant.

A. I'll bet you can't make that stick on the cross-examination stand.

Q. (Other speaker): Can any industry?

A. That's not the issue. We're not talking about the other industries. It can be said that we have "made it stick" so far in the nuclear business, and since we're still in the nuclear business, that's the standard that we'll be judged against.

Q. (T. H. Pigford): I'm still puzzled about your answer on the mill tailings. It was my understanding that NRC does license uranium mills, and the issue of mill tailings must surely be considered there. So why isn't there some precedent for that kind of consideration in licensing?

A. I'm not familiar with the details. I gather that the licensing that has started on mill tailings does indeed require stabilization. However, that does not address the question of the tailings that already exist.

Q. (R. F. Williams): I agree with your core concept: that too strict and too unthinking a safety analysis can certainly have an impact on the public acceptance of nuclear power. But you proceed from there to hypothesize that this unthinking safety analysis will lead

to either a finding that waste can't be disposed of or an undermining of public confidence in the licensing process. I disagree, because I think I can postulate a solution to the waste program given only that the safety review process is reasonably objective and rational.

- A. I'm not prepared to argue whether your view or mine will prevail. The only solid benchmark I have is the normally accepted technical review process of technical evidence. In the licensing process, if someone comes in with a document saying that he has some material that won't blow up until it reaches 130°F and he has six systems to keep the temperature down, he must present evidence to show that (1) the six systems will work; and (2) the 130°F is a valid figure. What I'm saying is that, in the waste management mode, we're going to have a hard time providing that level of assurance.

(R. F. Williams): It seems that, in addition to a philosophical difference of opinion, we also disagree specifically as to the level of technological backup available. I would conclude that the data available are sufficient to convince a reasonable regulator, and you would conclude that they are not.

- Q. (M. A. Molecke): You imply that there is a lack of data to prove the safety of this thing. There is currently a pilot plant program at Sandia that intends to measure many of these safety factors--for example, the effects of corrosion on canisters in the salt mine

environment, the transport migration of actinides, etc. I think that this program will provide us with many of the answers that you seem to think we cannot obtain.

- A. My only comment is that the concept of a long-term waste disposal pilot plant is philosophically absurd.

(R. L. Schwoebel): I agree very strongly with many of the things you said--particularly with regard to geologic storage, transport, and all the questions that may be raised regarding the impact on the biosphere. There's a whole series of important questions that have not nearly been answered. With regard to this conference, we're very long on methods and detailed technology of how to partition, but we're very short on trying to understand if we really need to partition, in terms of the kinds of questions you raised. I'd like to see two things come out of this conference: (1) a list of some critical experiments that we would propose to test these theories in the usual way--and these may be long-term experiments; and (2) some sort of consensus as to what sort of priority we'd place on this sort of research in terms of the number of dollars we'd assign to it--as opposed to spending millions again next year on the technology of partitioning.

- Q. (T. Hollocher): I wanted to make two comments. First, with respect to licensing agencies, it seems that such agencies need to consider two kinds of questions: (1) what is the hazard during normal operation; and (2) what happens in the case of a terrible

accident. With disposal, of course, in the normal operation there's no exposure at all, so only the second issue need be considered. Seco d, it seems like the Rasmussen study (WASH-1400) establishes an interesting precedent with respect to systems whose agreed-upon probability of failure is very low. People will take an event whose probability is highly improbable in the short range--let's say 10^{-12} of an event per year--and then extrapolate it out to periods on the order of 10^5 or 10^6 years.

- A. I have no basic disagreement. My only point would be that a Rasmussen study on waste disposal operations would be a one-page document. The Rasmussen study relies very heavily on existing experimental data and uses this information as the predictive mode. It says: "Here's what we've done so far and, assuming that we continue to be as smart as we have been, here's what we can expect in the future." My problem is that in our present situation, we can't even do the "here's what we've done now" part.

NUCLEAR REGULATORY COMMISSION

Docket No. PRM-50-18

Natural Resources Defense Council

Notice of Denial of Petition for Rulemaking

Notice is hereby given that the Nuclear Regulatory Commission (hereinafter "NRC" or "Commission") has denied a petition for rulemaking submitted by letter dated November 8, 1976 by the Natural Resources Defenses Council, Inc., 917 15th Street, N.W., Washington, D. C.

A notice of the filing of the petition, Docket No. PRM-50-18, was published in the FEDERAL REGISTER on January 13, 1977 (42 FR 2730) and interested persons were invited to comment on the petition by February 14, 1977. The comment period was subsequently extended to February 22, 1977 (42 FR 9735, February 17, 1977). Eighteen letters were received which recommended denial of the petition while two letters supported the petition. Copies of the comments are available for public inspection in the Commission's Public Document Room at 1717 H Street, N.W., Washington, D. C.

Natural Resources Defense Council, (hereinafter "NRDC") petitioned the Nuclear Regulatory Commission 1) to conduct a rulemaking proceeding to determine "whether radioactive wastes can be generated in nuclear power reactors and subsequently disposed of without undue risk to the public health and safety, and 2) to refrain from acting finally to grant pending

or future requests for operating licenses until such time as this definitive finding of safety can be and is made." (NRDC Petition, at 15). NRDC argued that the Commission is required by the Atomic Energy Act (42 U.S.C §§2011 et seq. (1972)) and the Energy Reorganization Act (42 U.S.C. §5801(a) (1972)) to ensure that the public health and safety are protected. The petitioner cited the requirements found in the Commission's regulations that the Commission must make a finding that "there is reasonable assurance that the activities authorized by the operating license can be conducted without endangering the health and safety of the public" and that "the issuance of the license will not be inimical to the health and safety of the public" (§50.57(a)(3) and (a)(6)) and from these requirements argued that the NRC must make a finding, prior to issuing an operating license for a reactor, that permanent disposal of high-level radioactive wastes^{1/} generated by that reactor can be accomplished safely.

In contrast, those comments which favored denial of the petition argued that long-term storage or disposal of high-level wastes is beyond the scope of licenses for reactors and, therefore, that no finding need be made regarding safe disposal of high-level wastes until the NRC licenses an

^{1/} The Commission's definition of high-level wastes, for purposes of this notice, is the same as petitioner's definition which includes high-level wastes as defined in 10 C.F.R. Part 50, App. F, spent fuel rods, and transuranic-contaminated wastes. (Petition, at 2).

actual facility to handle such disposal. The two comments supporting the petition stated that such wastes could not be disposed of safely but gave no evidence to support this conclusion.

After thorough study of the petition and exhibits submitted therewith and analysis of the comments, the Commission has concluded that it is not obligated to make a "definitive" finding, nor is it appropriate to make the "definitive" finding requested by NRDC, that safe methods of high-level waste disposal are now available prior to the licensing of a reactor. Because the petition seeks a finding that safe waste disposal can be accomplished immediately, the Commission has determined that the rulemaking petition should be denied. The Commission notes that prior to any licensing of high-level waste disposal facilities, a detailed finding concerning the safety of the proposed facilities will be made. There is, we believe, a clear distinction between permanent disposal of wastes and their interim storage. The Commission must be assured that wastes generated by licensed power reactors can be safely handled and stored as they are generated. As part of the licensing process for an individual power reactor facility, the Commission does review the facility in question in order to assure that the design provides for safe methods for interim storage of spent nuclear fuel. But it is neither necessary nor reasonable for the Commission to insist on proof that a means of permanent

waste disposal is on hand at the time reactor operation begins, so long as the Commission can be reasonably confident that permanent disposal (as distinguished from continued storage under surveillance) can be accomplished safely when it is likely to become ne . Reasonable progress towards the development of perman. disposal facilities is presently being accomplished. Under these circumstances a halt in licensing of nuclear power plants is not required to protect public health and safety.

Statutory Requirements

As petitioner states, the Atomic Energy Act clearly requires that some kind of safety finding be made prior to issuance of an operating license for a nuclear power reactor.

(NRDC Petition, at 4-9). Section 103d of the Act provides that no license for a production or utilization facility may be issued if, in the opinion of the Commission, the issuance of the license would be inimical to the health and safety of the public. It seems clear, however, that the statutory findings required by section 103 apply specifically to the "proposed activities" and "activities under such licenses." (42 U.S.C. §2133). These activities include some interim storage activities for spent fuel. They do not include the permanent disposal of high-level wastes though such wastes are, in fact, generated by operation of the reactor.

That detailed questions regarding the safety of permanent

disposal of these wastes are to be addressed in connection with the licensing of an actual high-level waste disposal facility, rather than in connection with licensing of reactor operation, is clear from the statutory treatment of radioactive wastes. 2/ Historically, the Atomic Energy Act has provided that nuclear materials licensing proceedings involving possession or use of nuclear materials off-site from the facility, which include high-level radioactive waste disposal proceedings, are to be treated as separate and distinct from the facility licensing proceeding itself. 3/ The Act provides for two-step facility licensing proceedings in Sections 101-106, and 185 of the Act in sharp contrast to the one-step licensing provisions relating to byproduct, source, and special nuclear material covered by Sections 53, 54, 57, 62, 63, 81 and 82. (42 U.S.C. §§2131-2136; 2235; 2073-74; 2077; 2092-93; 2111-12).

Section 182 of the Atomic Energy Act, which sets forth the information which must be supplied by an applicant for a facility license gives further support to the proposition that

2/ This point was raised in several of the comments. See comments of LeBoeuf, Lamb, Leiby & MacRae, at 6-7; Shaw, Pittman, Potts & Trowbridge, at 4-6, and 23-25; and Westinghouse, at 2-3.

3/ "Nuclear material" include special nuclear material defined in §11aa of the Act (42 U.S.C. §2014aa) and covered in §§51-58 of the Act (42 U.S.C. §§2071-78), source material which is defined in §11z of the Act (42 U.S.C. §2014z) and covered in §§61-69 of the Act (42 U.S.C. §§2091-2099), and byproduct material which is defined in §11e of the Act (42 U.S.C. §2014e) and covered in §§81-82 of the Act (42 U.S.C. §§2111-2112).

no safety finding regarding ultimate disposal of high-level wastes is required in a reactor operating license proceeding. (42 U.S.C. §2232). This section sets forth in some detail what an applicant for a license to operate a production or utilization facility must supply to enable the Commission to make the required safety finding. This information includes "the place of use [of special nuclear material], [and] the specific characteristics of the facility" as well as information regarding the technical and financial qualifications of the applicant.

The emphasis on information pertaining solely to the facility and applicant to be licensed is especially significant. No such information is required regarding high-level waste disposal facilities. Such information would be necessary were the Commission to make the detailed safety finding regarding high-level waste disposal activities requested by petitioner. Indeed, an applicant for a reactor operating license will have no responsibility for permanent disposal of high-level waste. (Appendix F, 10 C.F.R. Part 50).

This responsibility has been assumed by the Federal government, which, through ERDA, will research, design, build and operate high-level waste disposal facilities.

The statutory provisions cited above make it clear that no statutory requirement exists that the Commission determine the safety of ultimate high-level waste disposal activities

in connection with licensing of individual reactors.

Regulatory Requirements

With regard to the petitioner's contention that the Commission's regulations require a finding regarding the safety of ultimate disposal of high-level wastes, while the Commission's regulations do deal with the handling of spent fuel and other high-level wastes, they do so only to the extent that such activities are related to on-site activities carried on by the licensee as an integral part of operation of the reactor. This scheme of regulations has been in effect for some time, and the Commission's findings have been limited to those findings required by the Act and the Commission's regulations--"that there is reasonable assurance that the activities authorized by the operating license [the operation of the reactor] can be conducted without endangering the health and safety of the public" and "the issuance of the license will not be inimical . . . to the health and safety of the public." (10 C.F.R. §50.57(a)(3) and (a)(6)). These findings have not included findings with regard to safe permanent disposal of high-level radioactive wastes^{4/} and, as is pointed out below, have been implicitly approved by Congress.

^{4/} See General Design Criteria for Nuclear Power Plants, Appendix A, 10 C.F.R. Part 50. See also comments by LeBoeuf, Lamb, Leiby, and MacRae, at 10-12; and Shaw, Pittman, Potts, and Trowbridge, at 7-9.

Congressional ratification of NRC action

The scope of the Commission's safety findings is well known to Congress, as is the extent of the development of systems for high-level radioactive waste disposal. Congress has permitted continued licensing of reactors and the Commission has been given broad discretion in developing criteria for licensees. Such conduct constitutes implicit ratification of the Commission's handling of the high-level waste disposal question.^{5/}

As early as 1959, Congress held hearings on waste disposal problems.^{6/} Six days of hearings were held and the printed hearing materials totaled over 3,000 pages. The hearings were followed by a detailed Joint Committee survey analysis. At that time, development of a permanent high-level waste repository was further from completion than it is today. Congress was made aware of the fact that the problem of permanent disposal of high-level waste had not been solved and that several years of research and testing would be required before engineering practicality could be demonstrated.

During the hearing, the AEC described generally its regulatory program for radioactive waste disposal.^{7/} Comments regarding

^{5/} This point was made repeatedly in the comments. See comments by LeBoeuf, Lamb, Leiby and MacRae, at 7-8; Shaw, Pittman, Potts, and Trowbridge, 6-7, 15-28; and Troy B. Conner, at 3-4.

^{6/} "Industrial Radioactive Waste Disposal", "Hearings before the JCAE Special Subcommittee on Radiation, Jan. 28-30, Feb. 2-3, and July 29, 1959, 86th Cong., 1st Sess., (1959).

^{7/} Id. at 9-10.

regulatory aspects of the high-level radioactive waste disposal problem were confined to the brief statement that "for the foreseeable future, all high-level wastes resulting from processing of spent fuel elements from licensed reactors will be returned to the Commission for processing and handling."8/ Witnesses who testified in 1959 commented upon the Commission's handling of waste disposal problems, and one witness was questioned about whether he felt that the Commission had been meeting its responsibilities in the area of high-level waste disposal. He stated in response that the Commission had handled the problem quite well, but pointed out that temporary containment and custody was the only presently available method of handling high-level wastes and that a final and permanent solution to the problem might not ever be devised.9/

In later hearings, in 1973 and 74, some witnesses urged that a moratorium on licensing be imposed until a solution to the high-level waste disposal question was reached.10/ One

8/ Id. at 2515.

9/ Id. at 11-13.

10/ Hearing on S.2744 before the Senate Subcomm. on Reorg., Research and Int'l Org. of the Senate Comm. on Government Operations, 93rd Cong., 1st Sess., (1973), see particularly the prepared statement of Daniel F. Ford, Union of Concerned Scientists, at 210-215; Hearings on S.2135 and S.2744 before the Subcomm. on Reorg., Research, and Int'l Org. of the Senate Comm. on Government Operations, 93rd Cong., 2d Sess., (1974), testimony of Dr. Edward P. Radford, Johns Hopkins University, at 139, and prepared statements submitted by Sam Love, Environmental Action Foundation, at 141 and Anthony Roisman, at 212.

witness cited the high-level waste disposal problems as one of several problems which in his opinion warranted a moratorium on continued construction of nuclear power reactors,^{11/} and another witness stated that "many people have come to believe that present nuclear power plant construction plans which imply accumulations of more radioactive wastes, should be halted until a proven method for safely storing radioactive wastes is available."^{12/} The AEC in response described the existing proposals for long-term waste management and disposal, but made no claim that methods for permanent disposal had been developed.^{13/} Instead of ordering a moratorium on licensing, the Congress provided for NRC licensing of ERDA facilities for waste disposal in Sections 202(3) and (4) of the Energy Reorganization Act.

Thus, almost from the beginning of the reactor licensing program the basic issue presented by the NRDC petition--whether nuclear power reactors should be licensed in the absence of some "definitive" finding or conclusion that high-level wastes can be safely disposed of--was also presented to the Congress. Congress is and has been aware of the high-level waste disposal problem, aware of its connection to reactor operations,

^{11/} Id., testimony of Sam Love, at 141.

^{12/} Hearings on S.2135 and 2744, supra note 7, testimony of Daniel F. Ford, at 213.

^{13/} Hearings on S.2135 and 2744, supra note 7, at 336-47.

and aware that the Commission does not plan to defer licensing until the problem is resolved.

The question of continued licensing in the face of continued uncertainty respecting ultimate disposal technology is certainly a legitimate one to present to the Congress. It must make its judgments, as we do, with an eye to known prospects for the future, programs for implementing them, and current assessments of the risk that what is thought likely to succeed will in fact succeed. This Commission recognizes its responsibility to keep the Congress aware of its information and projections on these matters and has done so in the past. The Commission has confidence, given the on-going federal programs, that the problem of permanent disposal will be solved. This confidence was supported by the Congress when it passed major legislation dividing the Atomic Energy Commission into separate agencies and provided for NRC licensing of ERDA waste management facilities. At that time, it did not order a moratorium on reactor licensing and did not require that the Commission make specific findings with regard to high-level waste disposal in reactor licensing proceedings. As the Supreme Court said in Power Reactor Development Corp. v. Electrical Union with regard to Congress' failure to act regarding the Commission's safety findings at the construction permit and operating license stages:

It may often be shaky business to attribute significance to the inaction of Congress, but under these circumstances, and considering

especially the peculiar responsibility and place of the Joint Committee on Atomic Energy in the Statutory scheme, we think it fair to read this history as a de facto acquiescence in and ratification of the Commission's licensing procedure by Congress. 14/

In the instant case, Congress was clearly aware of the Commission's actions and the high-level waste disposal question, yet though major revisions of the legislation relating to the Commission's authority were made Congress neither amended the statutes to require such a finding nor did it direct the Commission to stop licensing reactors pending resolution of the waste disposal problem. Such a course of conduct reinforces the conclusion reached above, based on the clear language of the statute, that the Commission is not required to make a finding that radioactive wastes can be disposed of safely prior to the issuance of an operating license for a reactor. It presupposes, as well, a continuing dialogue between the Congress and the responsible federal agencies--a dialogue which has in fact been vigorous over the past months and promises to remain so. The Congress is entitled to the Commission's continuing assessment of this issue, and will have it.

Conclusion

NRDC cites several court cases in its petition in support of

14/ 367 U.S. 396, 409 (1961).

the proposition that the Commission must make a full safety finding prior to reactor licensing.^{15/} The Commission agrees with NRDC that these cases interpreting the statute indicate that a definitive safety finding regarding operation of the facility must be made prior to licensing a reactor. However, NRDC gives no support for its conclusion that this finding must extend to safe permanent disposal of high-level wastes, an activity not performed by the facility. To the contrary, the previous discussion demonstrates that there is no statutory requirement that the Commission determine that high-level radioactives wastes can be permanently disposed of safely prior to the issuance of an operating license for a reactor. The legislative materials cited above support the view that Congress did not and does not require that the Commission make the finding requested by NRDC. Accordingly, the Commission has decided to deny NRDC's petition for rulemaking.

Policy Consideration - Scope of a reasonable safety finding

The Commission believes that the direction and progress of the present overall high-level waste management program is satisfactory and provides a reasonable basis for continued licensing of facilities whose operation will produce nuclear wastes. Even if, contrary to the Commission's view, some kind of prior finding on waste disposal safety were required under the statutory scheme, such a finding would not have to

^{15/} Power Reactor Development Corp. v. Electrical Union, supra note 13; Nader v. NRC, 513 F.2d 1045(D.C.Cir. 1975) and Citizens for Safe Power v. NRC, 524 F.2d 1291(D.C.Cir. 1975).

be a definitive conclusion that permanent disposal of high-level wastes can be accomplished safely at the present time. There is no question that prior to authorizing operation of a reactor the Commission must find pursuant to Sec. 182 that hazards which become fully mature with start-up will be dealt with safely from the beginning. But the quality of this reactor safety finding can be readily distinguished from the quality of findings regarding impacts on public health and safety which will not mature until much later, if ever. The hazards associated with permanent disposal will become acute only at some relatively distant time when it might be no longer feasible to store radioactive wastes in facilities subject to surveillance. The Commission would not continue to license reactors if it did not have reasonable confidence that the wastes can and will in due course be disposed of safely. The accumulating evidence as discussed below continues to support the Commission's implicit finding of reasonable assurance that methods of safe permanent disposal of high-level wastes can be available when they are needed. Given this, and the fact that at present safe storage methods are presently available and highly likely to remain so until a permanent disposal system can be demonstrated and licensed, the Commission sees no reason to cease licensing reactors.

The technology for disposal is reasonably available, and the studies done to date, while not conclusive, are nevertheless promising for timely and safe implementation of the technology.

Most importantly, ERDA has dramatically expanded the U.S. program for development of a permanent high-level waste repository. ERDA has issued a report on technology for high-level waste repositories (ERDA-76-43), and has a programmatic EIS on high-level waste management in preparation. ERDA has greatly expanded its program for selection of sites for geologic disposal and is expected to apply to the NRC for a license for such a facility in early 1980 or before. In addition, ERDA is involved in programs to consider the effects on disposal of emplacement of spent fuel rods in a repository. Furthermore, it is involved in extensive programs to develop methods of stabilizing (e.g., solidifying) high-level wastes to provide for optimum safety during transportation, storage and disposal should reprocessing be commenced sometime in the future. Finally, ERDA is engaged in developing interim storage sites in case federal custody of wastes becomes necessary before a working repository is available. Thus, there is now a coordinated Federal program to develop an actual disposal facility. Similarly, the NRC is expanding its own program to set the regulatory requirements for such an operation. The NRC is presently developing a set of regulations to govern licensing of federal repositories to insure that permanent disposal of high-level radioactive wastes will be accomplished safely.

The NRC is also involved in several waste management related programs. The Commission recently completed an "Environmental Survey of the Reprocessing and Waste Management Portions of the

LWR Fuel Cycle:, NUREG-0116, which was published in October, 1976, and a companion document, NUREG-0216, published in March, 1977. In the survey the light water power reactor uranium fuel cycle was taken as including alternatively (1) no reprocessing of spent fuel and follow-on interim and/or long-term storage or disposal of spent fuel or (2) reprocessing spent fuel for purposes other than recycle of plutonium, with follow-on interim and/or long-term storage or disposal of plutonium and wastes from reprocessing, with plutonium either separated from or included with the wastes. This survey served as the basis for an interim rule (hereinafter "S-3") promulgated on March 14, 1977(42 F.R. 13803) which quantified the environmental impacts from the reprocessing and radioactive waste management portions of the nuclear fuel cycle alternatives described above. The survey generally concluded that these impacts were not significant. A final rulemaking proceeding will be held shortly.

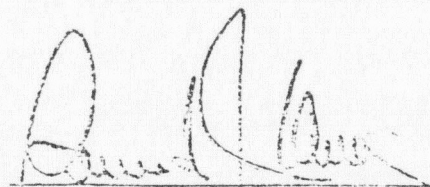
In addition, the Commission has been involved in a rulemaking proceeding on its final Generic Environmental Statement on the Use of Recycle Plutonium in Mixed Oxide Fuel in Light Water Cooled Reactors, NUREG-0002 (hereinafter "GESMO"). While the Commission has recognized that President Carter's statement of April 7, 1977 regarding reprocessing raises significant issues requiring a reassessment of the course of the GESMO proceedings (42 F.R. 22964, May 5, 1977), these proceedings to date have furnished the Commission with information on waste management

sufficient to convince the Commission that the technology for disposal does exist. More detailed information on NRC and ERDA programs is available in Appendices B and C of the S-3 Survey (NUREG-0116). It suffices to state here that these programs are designed to permit the NRC to meet its regulatory responsibilities in the field of waste management to protect the health and safety of the public. Of course, the additional work that is underway will produce more information on the technology and risks of high-level waste disposal and the momentum of the Federal program may change.

Beyond this, the selection and demonstration of an actual disposal site will likely be highly controversial, and a strong and continued national commitment to "get the job done" will likely be necessary. We see in the recent statements and actions of the Executive Branch regarding nuclear power and national energy policy, a firm commitment to carry through to completion a comprehensive high-level waste management program. Further, the Commission fully intends to press for vigorous pursuit of programs aimed at developing and implementing sound and timely arrangements for high-level waste disposal.

Dated at Washington, D.C. this 27th day of June, 1977.

FOR THE NUCLEAR REGULATORY COMMISSION



Samuel J. Chiles
Secretary of the Commission

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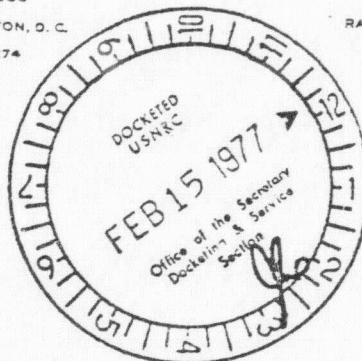
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February 14, 1977

Mr. Samuel J. Chilk
Secretary of the Commission
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Attention: Docketing and Service Section

(5)

USNRC Docket No. PRM-50-18

Dear Mr. Chilk:

On January 13, 1977, the Nuclear Regulatory Commission ("the Commission") published notice of a petition for rule-making by the Natural Resources Defense Council ("NRDC") in the Federal Register and invited comments by February 14, 1977. 42 Fed. Reg. 2,730 (1977). In that petition, the NRDC requests the Commission to hold a rulemaking to determine whether high-level radioactive wastes (defined by NRDC to include not only such material as defined by the Commission in 10 CFR Part 50, Appendix F, paragraph 2, but also spent fuel rods and transuranic contaminated wastes) can be

"generated in nuclear power reactors and subsequently disposed of without undue risk to the public health and safety." The petition further asserts that the Commission should refrain from issuing reactor operating licenses until such an affirmative finding can be made.

On behalf of Commonwealth Edison Company, Consolidated Edison Company of New York, Inc., The Detroit Edison Company, Exxon Nuclear Company, Inc., Niagara Mohawk Power Corporation, Omaha Public Power District, Power Authority of the State of New York, Public Service Company of Indiana, Inc., and Rochester Gas and Electric Corporation, we respectfully submit these comments urging the Commission to deny the petition for rule-making for the reasons set out below.

Summary

No one can disagree with the proposition that the public is entitled to reasonable assurance that nuclear energy activities can and will be conducted in a manner not inimical to the public's health and safety. However, to say that such assurance must be provided is not to say in what proceeding, or with what degree of detail, it must be provided. That assurance is provided at several distinct stages of decisionmaking with detail appropriate to the particularity of the decision being made. It is provided broadly by the Congress in authorizing and continuing the nuclear power program. It is also made by the Congress' regulatory agent, the Commission, in adopting

standards of general application and, finally, it is given in greatest detail when the Commission issues a particular license for a particular activity. The Congress and the Commission have continued to fulfill these responsibilities to make such findings at each level of their responsibility.

The petition confuses the Commission's delegated responsibility to issue licenses with the basic responsibility of Congress to authorize, and supervise the regulation of, the nuclear power program. Further, the petition confuses the Commission's responsibility under the Atomic Energy Act of 1954, as amended, ("Atomic Energy Act") to make a definitive finding of reasonable assurance of the public health and safety in the issuance of a particular reactor operating license with other responsibilities of the Commission. The Commission has a distinct responsibility under the National Environmental Policy Act of 1969 ("NEPA") which it has interpreted to include consideration of other activities (including the long-term storage of high-level wastes) in deciding on the issuance of the license, and the Commission has separate responsibilities under the Atomic Energy Act and the Energy Reorganization Act of 1974 to make findings for the issuance of standards and the licensing of other activities.

Insofar as the petition suggests that the Commission is not fulfilling its responsibilities for private licensed activities related to high-level wastes, transuranic-contaminated wastes, and spent fuel, through the issuance of standards and

licenses under the Atomic Energy Act, the petition is in error. The Commission has issued regulations and licenses governing such private activities after making the appropriate Atomic Energy Act findings, including health and safety findings, and continues to review and develop standards for regulation. The Commission's programs for waste management and reactor licensing have been under the continuous scrutiny of the Congress. Congress has not indicated that the definitive health and safety finding suggested by this petition is necessary or appropriate to the issuance of an operating license for a reactor.

In brief, it is the thrust of these comments that the petition should be denied because: (1) The Congress in enacting the Atomic Energy Act of 1954 made the general health and safety finding, appropriate to a legislature, that the nation has the ability to conduct all activities necessary to the nuclear fuel cycle, including the long-term management of high-level wastes, and has continued to reaffirm that finding in the exercise of its legislative and oversight powers; and (2) Definitive health and safety licensing findings on long-term high-level waste management activities are not appropriate to a power reactor operating license because Congress delegated to the Commission the authority to issue licenses on the basis of findings particular to the activities covered by each application; and (3) Congress has identified the long-term high-level radioactive waste management activity as an activity distinct from the operation of a power reactor and hence subject to a distinct license.

The Repeated Legislative Finding

In establishing the Atomic Energy Act Congress made the general findings, appropriate to the legislative function, that a private atomic energy industry, including by implication the wastes that such an industry would produce, could be conducted consistent with the health and safety of the public. 42 USC §§ 2011-2282 (1970 & Supp. V 1975) (in particular, 42 USC § 2011-1). The Congress was aware before the passage of the Atomic Energy Act that waste products would be created. As one witness testified, "... , we also have the materials found when uranium undergoes fission. These materials are strongly radioactive also and may be likened to the ashes of a conventional furnace." Hearings on S. 3323 and H.R. 8862 before the Joint Committee on Atomic Energy, 83d Cong., 2d Sess. 168 (1954). And another witness foresaw that there would come into being a supporting service industry for the "disposition of radioactive wastes." Id., at 583.

Congress has over the years held hearings to monitor carefully the continuing developments with respect to radioactive wastes, and in particular high-level wastes. E.g., Hearings on Chemical Reprocessing Plant before the Joint Committee on Atomic Energy, 88th Cong. 1st Sess. (1963). In 1959 alone, such hearings covered over 3000 pages. Hearings on Industrial Radioactive Waste Before the Joint Comm. on Atomic Energy, 86th Cong., 1st Sess. (1959) ("1959 Hearings"). Regularly those hearings have reviewed the progress of the

Government's own program as well as the licensing program. E.g., 1959 Hearings, 2509-31; Hearings on Radioactive Waste Management before the Subcomm. on Environmental Safety of the Joint Comm. on Atomic Energy, 94th Cong., 2d Sess. (1976) ("1976 Radioactive Waste Management Hearings").

A review of these hearings provides the reader with practical assurance that the Congress has been carefully monitoring the issue of radioactive waste management and had reason for confidence that the proper steps were, and are, being taken with respect to both regulation and the planning of Governmental facilities for the long-term storage of high-level radioactive waste. In other words, the continuation of the power reactor program with such detailed knowledge of the state of the radioactive waste program constitutes a continuing legislative finding of reasonable assurance under the doctrine of Power Reactor Devel. Co. v. International Union, 367 U.S. 396 (1961). However, two recent events provide even more positive evidence of the legislative determination that there is reasonable assurance of the health and safety of the public in the long-term storage of high-level radioactive waste.

In considering the Energy Reorganization Act of 1974, the Congress was told by at least one witness that "...present nuclear power plant construction plans, which imply accumulation of more radioactive wastes, should be halted until a proven method for safely storing radioactive wastes is available."^{1/} However, the Chairman of the Commission submitted

^{1/} Hearings on S.2744 before the Subcomm. on Reorganization, Research, and International Organizations of the Senate Comm. on Government Operations, 93d Cong., 1st Sess. 213 (1973).

testimony that there was at least one "thoroughly proven, safe, flexible technique" already available and others were under development and consideration.^{2/} In the conclusion of this overview, the Chairman stated that there would be "high assurance that there is minimum hazard to future generations from these activities."^{3/} The Congress did not decide to halt power reactor licensing but rather decided to require the Commission to license Federal long-term high-level waste facilities for commercial wastes which Congress recognized were not in existence and probably would not be until some future time "probably in the 1980's." S. Rep. No. 93-980, 93d Cong., 2d Sess. 60 (1974).

In fact, in the Energy Reorganization Act of 1974, the Congress established for the first time a specific requirement for the licensing of the Federal long-term storage of high-level radioactive wastes activities and recognized that such long-term storage facilities do not now exist. Section 202(3) and (4) of the Energy Reorganization Act of 1974; H.R. Rep. No. 93-1445, 93d Cong., 2d Sess. 34 (1974). We repeat that, there was no hint that power reactor licensing or any other licensing should in any way be delayed to await these separate licensing actions for long-term high-level waste management activities.

^{2/} Hearings on S. 2135 and S. 2744 before the Subcomm. on Reorganization, Research and International Organizations of the Senate Comm. on Government Operations, 93d Cong., 2d Sess. 338 (1974).

^{3/} Id., at 347.

Finally, in 1976, the Joint Committee on Atomic Energy issued a report which states as one of its "Conclusions" that ". . . , on the whole, the potential difficulties which may be encountered in the radioactive waste management program do not pose risks to the public of such magnitude that this Nation should forego its nuclear energy program," Ad Hoc Subcomm. to Review the Liquid Metal Fast Breeder Reactor Program, 94th Cong., 2d Sess., Review of National Breeder Reactor Program 12,79 (Joint Comm. Print 1976).

Thus, there are thorough repeated implicit and explicit findings by the Congress that the Nation can have long-term high-level waste storage facilities with a reasonable assurance of the public health and safety.

The Statutory Framework for Licensing

Congress established a statutory framework for licensing the nuclear industry and delegated to the Commission the responsibility to regulate that industry on the basis of individual licenses for individual activities subject to unique Congressional oversight.^{4/}

^{4/} Although the two Houses of Congress have distributed the legislative responsibilities of the Joint Committee to other Committees, this does not affect the special responsibility of the Congress to supervise the nuclear energy program under the Atomic Energy Act. S. Res. 4, 94th Cong., 1st Sess. (1977); H.R. Res. 5, 95th Cong., 1st Sess. (1977); 42 U.S.C. § 2252 (1970).

That statutory framework for licensing is set out in separate chapters of the Atomic Energy Act according to the activity to be licensed. The Commission's authority to issue licenses is described separately depending on whether the applicant for a license seeks to possess and use source material, byproduct material, special nuclear material, a utilization facility and/or a production facility. 42 USC §§ 2091-99, 2111-12, 2061-78, 2131-40 (1970 & Supp. V 1975) (respectively). The Atomic Energy Act also recognizes that a particular activity may require a license covering more than one of these conceptual categories. 42 U.S.C. § 2201(h) (1970). However, in each case, the findings to be made relate to the activity or activities for which the license is sought and the Commission is to make its determination whether to issue the license on the basis of the information in the application required by statute. Power Reactor Devel. Co. v. International Union, supra; 10 C.F.R. § 50.57 (1977).

Thus, we may look to the statutory scope of the contents of the application for a power reactor license for further assurance. The Act requires an application for a power reactor to state the

"...technical specifications, including information of the amount, kind, and source of special nuclear material required, the place of the use, the specific characteristics of the facility and such other information as the Commission may, by rule or regulation, deem necessary in order to enable it to find the utilization or production of

special nuclear material will be in accord with the common defense and security and will provide adequate protection to the health and safety of the public. " 42 USC §2232(a) (1970).

This information relates to a particular facility on a particular site to be constructed and operated by the applicant.

Further, if there ever were a possibility that a reactor licensee could seek a license for such long-term waste management activities, ^{5/} it is no longer. The Energy Reorganization Act of 1974 explicitly recognized that long-term high-level facilities will be subject to a separate license and that only the Government may be the licensee for such an activity. 42 U.S.C. § 5842(3) and (4) (Supp. V 1975). If long-term storage activities for high-level waste cannot be a part of any reactor license, such activities are beyond the scope of the Commission's responsibility to make any, much less a "definitive," finding of assurance to the public health and safety in the issuance of the power reactor license.

The logic of this approach is further supported by the nature and scope of the "definitive" finding. As set out in the statute and discussed by the Supreme Court in Power Reactor Devel. Co. v. International Union, supra, the licensing of a power reactor is a two stage process:

^{5/} E.g., 35 Fed. Reg. 17,530 (1971).

first a construction permit is approved and then, after construction, an operating license. The Commission will issue an operating license only if it can make the appropriate finding which the Court described variously as "positive" and "definitive." 367 U.S. at 406-07. In making the distinction between the degree of assurance of the public health and safety necessary for a construction permit and an operating license for a power reactor, the Court said: "The question is whether the first finding [that is, the construction permit] must be backed up with as much conviction as to the safety of the final design of the specific reactor in operation as the second, final finding [that is, the operating license] must be." 361 U.S. at 407. The Court explicitly recognized that this definitive finding could only be made after the "completion of construction" of the reactor and a review of "detailed safety data covering the final design of the petitioner's reactor." 367 U.S. at 411. This description carries no hint that the finding is intended to cover any activity not to be constructed under that construction permit. Rather, since the finding can be made only after the facility is completed under the construction permit, which is issued only after a finding of the assurance as to the general type of reactor and the site, the necessary inference is that the definitive finding applies only to the reactor authorized by that construction permit for that site.

Further, the Commission has consistently given this interpretation to the findings required by the Atomic Energy Act. In the period of more than 22 years since the passage of the Atomic Energy Act, the Commission has issued operating licenses for 63 power reactors without including the definitive finding requested by the petition. Also, Congress has considered and passed many amendments to the Atomic Energy Act, relating to both reactor licensing and waste disposal, but Congress has never amended that Act to require the Commission to make a definitive (or any other) health and safety finding as to long-term high-level waste management activities before a reactor operating license may issue. In view of the language of the Act and the Regulations, the continuous Congressional oversight, and the consistent administrative interpretation, we assert that Congress has approved the current licensing approach and does not intend that an Atomic Energy Act finding as to long-term high-level waste disposal should be made before an operating license for a reactor may issue.^{6/} As the Supreme Court has said:

No change in this procedure has ever been suggested by the Commission,....
It may often be shaky business to attribute significance to the inaction of Congress,

^{6/} Given the petitioner's definition of high-level waste some waste activities are conducted under the reactor license. As to those activities, as discussed below, the definitive health and safety finding is made.

but under these circumstances, and considering especially the peculiar responsibility and place of the Joint Committee on Atomic Energy in the statutory scheme, we think it fair to read this history as a de facto acquiescence in and ratification of the Commission's licensing procedure by Congress. Power Reactor Devel. Co. v. International Union, 367 U.S. 398, 408 (1961).

The flaw of the petition is that it ignores this ordered regulatory scheme of the Atomic Energy Act in three ways: It requests the most detailed level of Atomic Energy Act finding for an activity (in this case, a long-term high-level waste management facility), which finding is appropriate only to a license for a particular facility and then only after the facility has been completed, to be made (1) on a generalized basis, (2) before the waste management facility is constructed and long before Congress expected it to be constructed, and finally, (3) in the context of a license for a separate facility.

If Congress had found that the program for the management of high-level radioactive waste should be required to reach a certain state or that the Commission should be required to make some particular findings with respect to waste management activities, before operating licenses for power reactors could issue, it would have so required. It

has not done so.^{7/} The Commission should abide by this pattern of regulation.

This regulatory framework does not imply that the question of the long-term storage of high-level radioactive waste is excluded from any consideration in reactor licensing proceedings. To the contrary, the environmental effect of long-term high-level waste storage is included in the consideration of every reactor at both the construction permit and operating license stages pursuant to NEPA. Over four years ago, the Commission initiated a rulemaking and subsequently issued a rule setting forth the basis on which this and other fuel cycle activities should be included in

^{7/} This interpretation of the statutory pattern is well established. For example, one of the more active attorneys representing interests which have opposed the nuclear program recognized in extensive testimony before the Congress in 1974 that "[t]hese decisions on whether or not to go ahead with nuclear power, whether to have a breeder, whether nuclear waste disposal is such a problem that it cannot be dealt with and, therefore, in and of itself poisons the nuclear industry, are all questions that have ultimately to be resolved by Congress." Nuclear Power Plant Siting and Licensing: Hearings on H.R. 11957, H.R. 12823, H.R. 13484 and S.3179 before the Joint Comm. on Atomic Energy, 93d Cong., 2d Sess., Vol 1: Hearings, 77-140 (1974) (quoted material, 89; accord, 129) (emphasis added). And the same witness, in recommending the establishment of a "blue ribbon panel" for the debate of this and other issues, admitted in effect that the licensing of individual reactors did not provide a "forum" for this issue and that the issue was not appropriate to such individual reactor licensing actions. Id. at 95, 127-29.

the environmental consideration of reactor licenses. Petitioner was a participant in that rulemaking and the ensuing judicial review process. While vacating the rule on certain procedural grounds relating to reprocessing and waste management and remanding it for further proceedings, the U. S. Court of Appeals said it did not "dispute" the basic conclusion of the rule that the environmental effects of the entire fuel cycle are "insignificant" in the licensing of a reactor and, in fact, styled it a "fair summary." Subsequently, the Commission has initiated further rulemaking proceedings and has published for comment a new document, "Environmental Survey of the Reprocessing and Waste Management Portions of the LWR Fuel Cycle" (NUREG-0116). This document is an admirable venture in surveying all of the literature relevant to these subjects and making evaluations to provide the information to the Congress and the public for decision-making. To the extent that the petitioner is dissatisfied with the treatment of the waste management issue in that interim rulemaking petitioner may participate and has.

It is in this environmental aspect of the consideration of a reactor license that the U.S. Court of Appeals for the District of Columbia Circuit has indicated that there must be an adequate consideration of the fuel cycle (including high-level waste) effects, not in the safety findings. Natural Resources Defense Council v.

Nuclear Regulatory Commission, Nos. 74-1385, 74-1586 (D.C. Cir. July 21, 1976), cert. pend. sub nom., Vermont Yankee Power Corporation v. Natural Resources Defense Council, No. 76-419 (U. S.); see Scientists' Institute v. Atomic Energy Commission, 481 F.2d 1079 (D.C. Cir. 1973).

The Regulatory Pattern for Review of Waste Management Activities

We have indicated above, that while long-term high-level waste management is not subject to a definitive health and safety finding in the context of a reactor operating license, it is not excluded from the appropriate NEPA consideration in that proceedings. Further, we will sketch in outline the Commission's regulatory scheme and the on-going actions of other concerned agencies of the Government for wastes generally to emphasize further that this is not an area of inaction or ignorance.

However, first the definitional barrier must be removed. In 1971, the Commission defined "high-level liquid radioactive wastes" to be "those aqueous wastes resulting from the operation of the first cycle solvent extraction system, or equivalent, and the concentrated wastes from subsequent extraction cycles, or equivalent, in a facility for reprocessing irradiated reactor fuel" and directed that those wastes shall be converted into dry solid for transfer to a Federal repository. 10 CFR Part 50, Appendix F, ¶2 (1977). Thus, from a purely semantic point of view, it may be said that the reactor operator never has possession

or control of "high-level" wastes, that the reprocessor has possession and control for only the short, or "interim", period, and therefore it is only the Government which has "long-term, high-level" waste storage responsibilities.

If we consider the petition's broader definition, we find that both the reactor operator and others have some responsibility for "spent fuel rods" and "transuranic-contaminated" wastes.

With respect to high-level wastes and all other wastes, the Commission has issued standards through regulations, and issued licenses after making the appropriate health and safety findings. Further, there is a variety of rulemakings underway to consider new and perhaps yet more stringent standards. The Commission early on recognized that there would be a continuing process of upgrading standards. 1959 Hearings, at 2516. And the federal courts have held that the consideration of new standards does not invalidate the existing ones. Nader v. Nuclear Regulatory Commission, 513 F.2d 1045, 1054 (D.C.Cir. 1975).

In the issuance of Appendix F, the Commission found with respect to public health and safety considerations that there was an

"...availability of technology for solidifying the high-level waste in forms suitable for safe transport to and disposal at a Federal repository specially selected and designed for permanent removal of such radioactive wastes from the biosphere, and (2) a recognition that fuel reprocessing plants can be so designed that radiologically significant contaminants may

be removed or otherwise satisfactorily disposed of when the plant is retired from operational service." Statement of Consideration ¶2, 35 Fed. Reg. 17,530 (1970).

While these findings discussed the Lyons, Kansas, project in particular, the abandonment of that particular project does not vitiate the general findings. See, e.g., ERDA, Alternatives for Managing Wastes from Reactors and Post-Fission Operations in the LWR Fuel Cycle (ERDA-76-43) passim (1976); ERDA, Proceedings of the International Symposium on the Management of Wastes from the LWR Fuel Cycle, (CONF-76-0701) 137-89 (1976).

The management of spent fuel at the reactor is evaluated on the basis of information submitted in the Preliminary and Final Safety Analysis Reports in accordance with the Regulations and Regulatory Guides. And its shipment to a fuel reprocessing plant or an independent irradiated fuel storage is covered by regulatory standards issued by the Commission and the Department of Transportation. Further, the Commission has established regulatory standards for such reprocessing plants and storage facilities. See, e.g., Regulatory Guides 3.26 and 3.24, respectively. Thus at each stage of its existence (at the reactor, in transportation, and in storage) the spent fuel is under the appropriate license issued after the health and safety findings have been made.

With respect to transuranic waste,^{8/} there is currently in force a system of regulation, including criteria, covering the possession of transuranic wastes by licensees (including reactor licenses) as well as the transportation and disposal of such wastes. E.g., 10 C.F.R. Parts 20, 30, 31, 33, 50, 70, and 73 (1977). Further, the Commission has issued licenses after making appropriate findings under those regulations by the Commission, including health and safety findings. The Commission has under consideration a proposed rule to define further the responsibility for the disposal of such wastes. Transuranic Waste Disposal, Proposed Standards for Protection Against Radiation, 39 Fed. Reg. 32, 921 (1974). If that rule is adopted as proposed, disposal of transuranic wastes would be a government activity and, thus, would not be within the scope of the activity under any private license.

None of the foregoing is intended to suggest that the Commission has taken all the actions necessary to establish a complete body of regulatory standards for reprocessing plants or high-level waste management activities.

^{8/} There is no regulatory or other common definition. However, as part of a proposed rule, the Commission is considering such wastes as "[w]aste material containing or contaminated with transuranium elements (atomic number greater than 92)." 10 C.F.R. § 20.306 (proposed), 39 Fed. Reg. 32,921 (1974).

The Commission and the Congress have both recognized that this is an on-going ever evolving task. What the Commission had done is to establish a pattern of treatment of these matters which is fully consistent with the governing legislation and which this rulemaking petition ignores.

Thus, with respect to both spent fuel and transuranic wastes, the Commission has made the findings petitioner seeks in the establishment and continuing development of standards for licenses and in the actual issuance of licenses. Insofar as a power reactor license includes activities related to spent fuel and transuranic wastes, information on such activities is required in the application and the finding of reasonable assurance of the health and safety of the public is made before the operating license is issued. See, e.g., Regulatory Guide 1.70, Revision 2 (NUREG-75-094) Sections 9.1 and 13.5.2.2 (1975); see, also, Regulatory Guides 1.13 and 1.25.

Conclusion

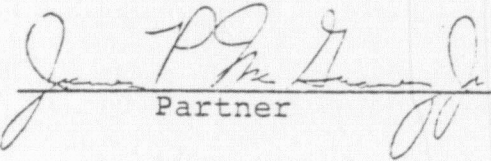
The rulemaking requested by the petitioners should be denied by the Commission (1) because it is inconsistent with the structure of the Atomic Energy Act and the Regulations, as reviewed and approved by Congress and the Courts, (2) because the appropriate health and safety standards and determinations for relevant waste management activities have been made by the Commission within the context of the regulatory standards and individual licensing actions, and

finally, (3) because Congress has established the appropriate forum for the consideration of long-term high-level waste management, namely, in the licensing of Government-owned waste facilities pursuant to Section 202 of the Energy Reorganization Act of 1974.

Respectfully submitted,

LeBOEUF, L. B., LEIBY & MacRAE

By


Partner

(9)

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DOCKET NUMBER
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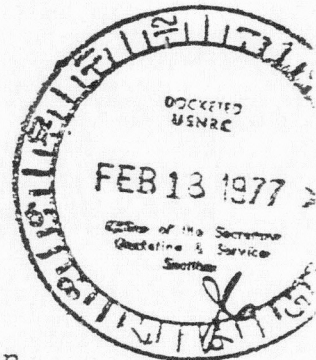
JOHN H. SHARON
COUNSEL

February 14, 1977

Secretary of the Commission
U.S. Nuclear Regulatory Commission
Washington, D. C. 20555

ATTN: Docketing and Service Section

Re: Petition of the Natural Resources
Defense Council for a Determination,
Prior to Issuance of Reactor Operating
Licenses, Whether Radioactive Wastes Can
Be Disposed of Safely,
Docket No. PRM-50-18



Gentlemen:

On January 13, 1977, the Nuclear Regulatory Commission ("Commission") published a notice in the Federal Register that the Natural Resources Defense Council, Inc. ("NRDC") on November 8, 1976 had filed a petition for rulemaking. 42 Fed. Reg. 2730 (1977). The NRDC Petition ("Petition") requested the Commission

(1) to conduct a rulemaking for the explicit purpose of determining whether radioactive wastes can be generated in nuclear power reactors and subsequently disposed of without undue risk to the public health and safety, and (2) to refrain from acting finally to grant pending or future requests for reactor operating licenses until such time as this definitive finding of safety can be and is made.

Acknowledged by card 2/18/77

Petition at 15. The notice stated that written comments or suggestions concerning the Petition could be submitted by February 14, 1977.

We are pleased to submit the following comments on behalf of American Electric Power Company, Baltimore Gas and Electric Company, The Cleveland Electric Illuminating Company, Duquesne Light Company, General Public Utilities Corporation (and its subsidiaries Jersey Central Power & Light Company and Metropolitan Edison Company), Ohio Edison Company, Pennsylvania Power and Light Company, the SNUPPS utilities (Kansas Gas and Electric Company, Kansas City Power & Light Company, Northern States Power Company, Rochester Gas and Electric Company, and Union Electric Company), The Toledo Edison Company, Wisconsin Electric Power Company, Madison Gas and Electric Company, Wisconsin Power and Light Company, and Wisconsin Public Service Company. Each of these companies has a strong interest in the outcome of this rulemaking proceeding as a holder of one or more operating licenses, construction permits or limited work authorizations or as the applicant for these licenses, permits or authorizations. These companies collectively represent nuclear power reactors in operation or in various stages of the licensing process having a capacity of approximately 88,000 MW(t). On behalf of these utilities, we respectfully request that the Petition be denied.

The NRDC Petition asserts that the Atomic Energy Act of 1954, the Energy Reorganization Act of 1974, and the Commission's regulations require that the Commission "make a definitive safety finding whether high-level radioactive wastes can be safely disposed of without undue risk to the public health and safety", ^{1/} Petition, at 1-2, before the Commission can issue operating licenses to nuclear power reactors. NRDC's analysis begins by referring to the Commission's statutory and regulatory obligation to protect the health and safety of the public. NRDC observes that at the construction permit stage, a permit for a reactor can be issued "even if further research and development is required for needed safety features or components", Petition at 6. NRDC contrasts this with the requirement at the operating license stage that "a definitive safety finding would have to be made before operation [of a nuclear power reactor] was actually permitted", Petition at 8.

Based solely on these very broad principles which underlie NRC licensing, NRDC concludes that the "definitive safety finding" to be made before an operating license for a nuclear power reactor can be issued must include a finding

^{1/} "High-level radioactive wastes" are defined by the Petition as "(1) high-level wastes as defined in 10 C.F.R. Part 50 Appendix F, (2) spent fuel rods, and (3) transuranic-contaminated wastes." Petition at 2, fn. 1.

that the disposal of high-level radioactive waste can be accomplished safely. The only justification for this conclusion is that a nuclear power reactor inevitably produces high-level radioactive wastes. As stated in the Petition at 9-10,

One of the inevitable by-products of operating a nuclear power reactor is the creation of massive amounts of plutonium and other highly radioactive materials. During its projected 40-year life span, a one-thousand megawatt nuclear power plant can be expected to generate eight metric tons of plutonium, as well as millions of curies of other highly toxic radioactive materials. Plainly a determination that operation of such a reactor will not create undue risk to the public health and safety requires a determination that these highly hazardous and long-lived radioactive materials can be disposed of safely. (footnote omitted)

We believe the NRDC's argument is fatally flawed in that NRDC has misread the relevant statutes and regulations, ignored Commission precedent, failed to analyze applicable case law, and neglected to consider Congressional intent and understanding. The Commission has adopted a licensing approach in which safety findings are made for the facility to be licensed and for the activities authorized under that license. NRDC attempts to impose on the Commission the obligation to make the radiological health and safety findings required under the Atomic Energy Act and the Commission's implementing regulations for activities beyond the scope of the specific operating license. This scheme finds no support in the

actions of Congress, the Commission or the courts. The Commission should therefore reject NRDC's attempt to rewrite applicable statutes, regulations and judicial decisions. At the same time, the Commission should forcefully point out to NRDC that it has made all necessary findings on the disposal of radioactive waste.

I. THE COMMISSION'S LICENSING PROCESS IS BASED UPON RADIOLOGICAL HEALTH AND SAFETY FINDINGS FOR THE PARTICULAR FACILITY UNDER CONSIDERATION AND THE ACTIVITIES TO BE AUTHORIZED BY A SPECIFIC LICENSE.

There can be no doubt that the Commission^{2/} has since its inception issued operating licenses (as well as construction permits) for nuclear power reactors based upon an analysis of the safety of the particular facility and of the safety of the activities to be conducted pursuant to the specific license. In no case has the Commission made safety findings in licensing a nuclear power reactor (or any other facility) which extend beyond the scope of that license or reach activities which would be covered by other licensing actions (such as reprocessing or waste disposal). No reactor operating license issued by the Commission has incorporated conditions, limitations or technical specifications concerning

^{2/} Except where the context otherwise requires, reference to the Commission includes both the Nuclear Regulatory Commission and the licensing and regulatory functions of the Atomic Energy Commission transferred to the NRC by sec. 201(f) of the Energy Reorganization Act of 1974, 42 U.S.C. §5841

the disposal of high-level radioactive waste (or indeed other phases of the nuclear fuel cycle). The licensee of an operating power reactor has no authority to dispose of high-level radioactive wastes. From the start of the Commission's regulatory program, it has licensed each facility separately, without requiring an overall safety finding on each other phase of the nuclear fuel cycle.^{3/} NRDC, having "been involved in many proceedings involving the Atomic Energy Commission and now the Nuclear Regulatory Commission", Petition at 3, is certainly aware of this. The fact that the Commission has employed the same procedure in every instance is itself of weight in determining its appropriateness. See Power Reactor Development Co. v. International Union, 367 U.S. 396, 409 (1961).

The Commission's interpretation was well known to the Joint Committee on Atomic Energy. For example, in 1959 testimony on sec. 274, §42 U.S.C. §2021, the AEC clearly stated that control over each phase of the nuclear fuel cycle was exercised in connection with the licensing of the particular activities of that phase.

^{3/} While NRDC's Petition only addresses the asserted requirement for a safety finding on high-level radioactive waste disposal in connection with reactor licensing, the logic of its argument would require the same safety finding for every other phase of the nuclear fuel cycle, and perhaps even non-nuclear activities which inevitably result from nuclear power reactors.

Under the licenses which we issue for the operation of nuclear reactors, we would have control over the shipment of any irradiated fuel elements from the facility to a chemical reprocessing plant under this bill. There are not any licensed chemical reprocessing plants. They would fall in the same category as reactors under this bill so we would continue our regulatory controls over the reprocessing plant and shipment of the high level waste products from that plant.

Hearings on Federal-State Relationships in the Atomic Energy Field before the Joint Comm. on Atomic Energy, 86th Cong., 1st Sess., 306.

The Commission's practice is consistent with the regulations which the Commission has promulgated to govern the licensing of reactors. The General Design Criteria for Nuclear Power Plants,

establish the necessary design, fabrication, construction, testing and performance requirements for structures, systems and components important to safety; that is structures, systems and components that provide reasonable assurance that the facility can be operated without undue risk to the health and safety of the public.

App. A to 10 C.F.R. Part 50, Introduction. Nowhere do the General Design Criteria impose any requirements as to the disposal of high-level radioactive waste (or to other activities beyond the scope of the reactor license).^{4/}

The requirements are addressed to the structures, systems

^{4/} The Commission has, of course, begun rulemaking proceedings to establish General Design Criteria for fuel reprocessing plants. See proposed Appendix P, 10 C.F.R. Part 50, 39 Fed. Reg. 26293 (1974). These criteria would be applied in licensing proceedings for reprocessing plants. The Commission is also developing performance criteria for high-level wastes as well as site selection criteria and other applicable regulations for waste management. Hearings on Radioactive Waste Management before the Subcomm. on Environ. and Safety of the Joint Comm. on Atomic Energy, 94th Cong., 2d Sess., 20-21, 251, 281-284 (1976).

and components of the facility. Similarly, the Commission's regulations which specify the information to be supplied by an operating license applicant for the Commission's safety review are addressed to the facility under consideration, not to activities beyond its scope.

The final safety analysis report shall include information that describes the facility, presents the design basis and limits of its operation, and presents a safety analysis of the structures, systems, and components and of the facility as a whole. . . .

10 C.F.R. §50.34(b) (emphasis added). See also 10 C.F.R. §50.34(a) (preliminary safety analysis reports). The financial information which an applicant must submit shall demonstrate the financial qualifications "to carry out. . . the activities for which the permit or license is sought." 10 C.F.R. §50.33(f). Similarly, technical specifications are to be addressed to the facility for which a license is sought, not to some broader scope of activities. 10 C.F.R. §50.36.

NRDC's argument relies in large part on the general safety findings which the Commission makes on issuing a reactor operating license:

(1) Construction of the facility has been substantially completed, in conformity with the construction permit and the application as amended, the provisions of the Act, and the rules and regulations of the Commission; and

(2) The facility will operate in conformity with the application as amended, the provisions of the Act, and the rules and regulations of the Commission; and

(3) There is reasonable assurance (i) that the activities authorized by the operating license can be conducted without endangering the health and safety of the public, and (ii) that such activities will be conducted in compliance with the regulations in this chapter; and

(4) The applicant is technically and financially qualified to engage in the activities authorized by the operating license in accordance with the regulations in this chapter; and

(5) The applicable provisions of Part 140 of this chapter have been satisfied; and

(6) The issuance of the license will not be inimical to the common defense and security or to the health and safety of the public.

10 C.F.R. §50.57(a). In particular, NRDC points to the third and sixth findings as mandating broader safety findings than the Commission has ever made. Petition at 1, 7. As to the third finding ("reasonable assurance"), NRDC fails to realize that this provision applies to the "activities authorized by the operating license." An operating license for a nuclear power reactor does not authorize the disposal of high-level radioactive waste, a subject considered in other proceedings.^{5/} As to both the third and the sixth

^{5/} For example, section 202 of the Energy Reorganization Act of 1974, 42 U.S.C. §5842, explicitly grants the Commission licensing and related regulatory authority for

(3) Facilities used primarily for the receipt and storage of high-level radioactive wastes resulting from activities licensed under [the Atomic Energy] Act.

(4) Retrievable Surface Storage Facilities and other facilities authorized for the express purpose of subsequent long-term storage of high-level radioactive waste generated by the [Energy Research and Development] Administration, which are not used for, or are part of, research and development activities.

findings, NRDC ignores the Commission's consistent interpretation that the relevant scope of inquiry is the specific facility and the activities authorized by the specific license. This interpretation has been upheld by the courts. In discussing the meaning of "common defense and security" and "the public health and safety", judicial decisions have looked to the specific facility or activity being licensed, not some broader scope. Thus, in Siegel v. Atomic Energy Commission, 130 U.S.App.D.C. 307, 400 F.2d 778, 784 (1968), in holding that action by foreign enemies need not be considered, the Court stated that

Congress certainly can be taken to have expected that an applicant for a license should bear the burden of proving the security of his facility as against his own treachery, negligence, or incapacity. (emphasis added).

Similarly, the Court of Appeals in Nader v. Nuclear Regulatory Commission, 169 U.S.App.D.C. 255, 513 F.2d 1045, 1052 (1975), in discussing the General Design Criteria stated,

As a precondition to granting of a license for operation of a nuclear facility, the Atomic Energy Act explicitly requires a Commission finding that the licensed facility will afford 'adequate protection to the health and safety of the public.' (emphasis added)

See also North Anna Environmental Coalition v. U.S. Nuclear Regulatory Commission, ____ U.S.App.D.C. ____, 533 F.2d 655, 659 (1976).

II. THE COMMISSION'S REGULATIONS AND PRACTICE NOT REQUIRING A "DEFINITIVE FINDING OF SAFETY" ON THE DISPOSAL OF HIGH-LEVEL RADIOACTIVE WASTES ARE IN ACCORD WITH THE BROAD GRANT OF REGULATORY AUTHORITY CONFERRED ON THE COMMISSION BY CONGRESS.

The Commission's regulatory practice is fully in accord with the broad regulatory mandate which the Congress has given to the Commission. The Commission's licensing and regulatory functions are governed by broad policy statements set forth in the Atomic Energy Act. For example, Congress found that

c. The processing and utilization of source, byproduct, and special nuclear material affect interstate and foreign commerce and must be regulated in the national interest.

d. The processing and utilization of source, byproduct, and special nuclear material must be regulated in the national interest and in order to provide for the common defense and security and to protect the health and safety of the public.

e. Source and special nuclear material, production facilities, and utilization facilities are affected with the public interest, and regulation by the United States of the production and utilization of atomic energy and of the facilities used in connection therewith is necessary in the national interest to assure the common defense and security and to protect the health and safety of the public.

Sec. 2.c, d, e (42 U.S.C. §2012(c), (d), (e)). Similarly, the purposes of the Atomic Energy Act include providing for

c. a program for Government control of the possession, use and production of atomic energy and special nuclear materials, whether owned by the Government or others, so directed as to make the maximum contribution to the common defense and security and the national welfare

d. a program to encourage widespread participation in the development and utilization of atomic energy for peaceful purposes to the maximum extent consistent with the common defense and security and with the health and safety of the public.

Sec. 3.c, d (42 U.S.C. §2013(c), (d)).

Congress has given NRC an extremely broad degree of responsibility to achieve these statutory objectives by granting to the Commission rulemaking power unfettered by close restraint. For example, section 103.a, 42 U.S.C. §2133(a), authorizes the Commission to license nuclear power reactors for industrial or commercial purposes

in accordance with the provisions of Chapter 16 and subject to such conditions as the Commission may by rule or regulation establish to effectuate the purposes and provisions of this Act.

Section 161.b, 42 U.S.C. §2201(b), authorizes the Commission to

establish by rule, regulation, or order, such standards and instructions to govern the possession and use of special nuclear material, source material, and byproduct material as the Commission may deem necessary or desirable to promote the common defense and security or to protect health or to minimize danger to life or property.

Section 161.i, 42 U.S.C. §2201(i), authorizes the Commission to

prescribe such regulations or orders as it may deem necessary . . . to govern any activity authorized pursuant to this Act, including standards and restrictions governing the design, location, and operation of facilities used in the conduct of

such activities, in order to protect health and to minimize danger to life and property.

Section 161.p, 42 U.S.C. §2201(p), authorizes the Commission to

make, promulgate, issue, rescind, and amend such rules and regulations as may be necessary to carry out the purposes of this Act.

Section 182.a, 42 U.S.C. §2232(a), provides in part,

In connection with applications for licenses to operate production or utilization facilities, the applicant shall state such technical specifications, including information on the amount, kind, and source of special nuclear material required, the place of use, the specific characteristics of the facility, and such information as the Commission may by rule or regulation, deem necessary in order to enable it to find that the utilization or production of special nuclear material will be in accord with the common defense and security and will provide adequate protection to the health and safety of the public.

Of particular interest is the language in sections 161.i and 182.a quoted above where Congress focuses particular attention on standards, restrictions and information for the specific facility being licensed.

The Courts have on many occasions affirmed the broad discretion with which Congress has entrusted the Commission. As stated by the U.S. Court of Appeals for the D.C. Circuit in Siegel v. Atomic Energy Commission, supra, 400 F.2d at

Congress agreed [with the Presidential Message that flexibility was needed] by enacting a regulatory scheme which is virtually unique in the degree to which broad responsibility is reposed in the administrative agency, free of close prescription as to how it shall proceed in achieving the statutory objectives.

See also North Anna Environmental Coalition v. U.S. Nuclear Regulatory Commission, *supra*, 533 F.2d at 658-659; Union of Concerned Scientists v. Atomic Energy Commission, 163 U.S. App.D.C. 64, 499 F.2d 1069, 1076-1077, 1079 (1974); BPI v. Atomic Energy Commission, 163 U.S.App.D.C. 422, 502 F.2d 424, 428 (1974).

As a result of this unique degree of responsibility, courts have been willing to give great weight to NRC's interpretation of its organic statute and its regulations. Northern Indiana Public Service Co. v. Porter County Chapter of the Izaak Walton League of America, Inc., 423 U.S. 12, 96 S.Ct. 172, 173-174 (1975); Power Reactor Development Co. v. International Union, *supra*, 367 U.S. at 408-409; North Anna Environmental Coalition, *supra* at 667; Northern States Power Co. v. State of Minnesota, 447 F.2d 1143, 1152 (8th Cir. 1971), *aff'd* 405 U.S. 1035 (1972)^{6/}

^{6/} Courts have also pointed to the special relationship between the Commission and the Joint Committee on Atomic Energy as one of the bases for according great weight to Commission interpretations. *See, e.g., Power Reactor Development Co., supra*, at 408-409. Although the present Congress has all but abolished the Joint Committee, this fact has no bearing on the present inquiry since the interpretation of the Commission's authority discussed herein depends not on any recent action, but on a consistent practice over a period of many years.

The Commission by regulation and practice has separately dealt with radiological health and safety aspects of each phase of the nuclear fuel cycle. It has considered the safety aspects of reactors in its licensing of reactors, the safety aspects of reprocessing facilities in its licensing of reprocessing facilities. It is required to consider the radiological health and safety aspects of high-level radioactive waste disposal facilities when it considers the licensing of such facilities. Sec. 203(3) and (4), Energy Reorganization Act of 1974, 42 U.S.C. §5842. NRDC has pointed to nothing which mandates a different approach.^{7/} The broad regulatory mandate given the Commission by Congress clearly permits this method of regulation.

III. NRDC'S PETITION IS TOTALLY INCONSISTENT WITH THE UNDERSTANDING OF CONGRESS AS TO THE STATUS OF RADIOACTIVE WASTE DISPOSAL.

For many years, Congress has been actively involved with the problems of storage and disposal of high-level radioactive waste. Numerous hearings have heard testimony

^{7/} Whether the Commission could, in its discretion, undertake a rulemaking proceeding for the purpose of making a "definitive finding of safety" on the disposal of high-level radioactive waste is, of course, not at issue here.

on the subject, with the first full-scale presentation in 1959.^{8/} At the same time, Congress had exercised its oversight of the Commission's reactor licensing programs, including several amendments to the Atomic Energy Act's licensing provisions. At no time did Congress indicate any inconsistency between the program to develop the technology for storing and disposing of radioactive wastes and the continued issuance of operating licenses for nuclear power reactors. At no time did Congress seek to have the Commission stop issuance of operating licenses pending further development of radioactive waste disposal or to amend the Atomic Energy Act to require an operating license to be preceded by a "definitive finding of safety" on high-level radioactive waste disposal. With awareness since at least 1959 of these dual circumstances by Congress and the Joint Committee on Atomic Energy,

it is fair to read this history as a de facto awareness in and ratification of the Commission's licensing procedure by Congress.

Power Reactor Development Co. v. International Union, supra at 1036.

^{8/} See, e.g., Hearings on Industrial Radioactive Waste Disposal before the Special Subcomm. on Radiation of the Joint Comm. on Atomic Energy, 86th Cong., 1st Sess. (1959).

Although NRDC's Petition does not explicitly define what it means by a "definitive finding whether high-level radioactive wastes can be safely disposed of without undue risk to the public health and safety", it appears that NRDC would require the same type and detail of information which the Commission requires for its radiological health and safety review prior to the issuance of a reactor operating license. If Congress had in fact intended that the Commission, as a precondition for the issuance of operating licenses under the Atomic Energy Act, make safety findings for waste disposal of the type made for power reactors, then no operating licenses would ever have been issued. Congress has been aware of both the absence of such an "definitive finding" and of the issuance of reactor operating licenses; yet it has never sought to halt the granting of operating licenses.

Since 1959, hearings before the Joint Committee on Atomic Energy, the House and Senate Appropriations Committees, and the House Interior Committee have kept Congress informed on the state of research and development efforts in radioactive waste disposal. The 1959 hearings focused largely on liquid storage in tanks, but with a realization that a more suitable form for storing wastes was necessary. Hearings, supra note 8, at 2345-54. In 1961, "preliminary results" of the field program on using salt structures were described;

an AEC witness stated that a pilot plant to study calcination had been completed. Hearings on Development of the Atomic Energy Industry before the Joint Comm. on Atomic Energy, 86th Cong., 1st Sess., 15-16 (1961). In 1962, Chairman Seaborg described ongoing research on solidification before the Joint Committee. Hearings on AEC Authorizing Legislation Fiscal Year 1963 before the Subcomm. on Legislation of the Joint Comm. on Atomic Energy, 87th Cong., 2d Sess., 97-98 (1962). The 1962 Civilian Nuclear Power - A Report to the President, stated that the "problem [of developing methods for ultimate storage of high-level wastes] is technically soluble" and was still in the "research stage". Reprinted in Report of the Joint Comm. on Atomic Energy, Nuclear Power and Related Energy Problems - 1968 through 1970, 92d Cong., 1st Sess., Appendix 1 at 299 (1971). In 1965, prototype demonstrations, laboratory investigation and field studies in solidification and storage technologies were described. Hearings on AEC Authorizing Legislation Fiscal Year 1966 before the Joint Comm. on Atomic Energy, 89th Cong., 1st Sess., 875-876, 1217-1218 (1965). In 1967, the Commission described the need to develop and demonstrate the solidification and geologic storage of high level wastes.

AEC, Civilian Nuclear Power - 1967 Supp. to the 1962 Report to President, reprinted in Report of the Joint Comm. on Atomic Energy, Nuclear Power and Related Energy Problems -1968 Through 1970, supra at 439. The 1968 authorization hearings heard a presentation on the status of solidification (in the engineering demonstration phase) and long-term geologic storage (in the field testing stage). Hearings on AEC Authorizing Legislation Fiscal Year 1969 before the Joint Comm. on Atomic Energy, 90th Cong., 2d Sess., Pt. 1, 704 (1968). At the 1970 authorization hearings, AEC discussed "three candidate means for solidifying wastes from reprocessing plants" and the need to design a geologic repository. Hearings on AEC Authorizing Legislation Fiscal Year 1970 before the Joint Comm. on Atomic Energy, 91st Cong., 2d Sess., 1424 (1970). The 1973 appropriations hearing included a request by the AEC for funds "for the development of methods that can be brought into operation in the near future for the safe acceptable management of commercially generated high-level wastes to be delivered to the Commission under its present regulations." Hearings on Public Works for Water, Pollution Control, and Power Development and Atomic Energy Commission Appropriations for Fiscal Year 1973 before a Subcomm. of the Senate Appropriations Comm., 92d Cong., 2d Sess., 213 (1972). In 1973, the AEC informed

the Joint Committee that it was focusing near term effort in design and construction of a retrievable surface storage facility while reexamining all alternative long-term storage options. Hearings on Nuclear Reactor Safety before the Joint Comm. on Atomic Energy, 93d Cong., 1st Sess., 179-278 (1973). In 1975 ERDA testified that

effective management of nuclear wastes in a manner which effectively protects man and his environment still has major unsolved problems. The ERDA program has progressed to the point where solutions to each of these problems can be anticipated with confidence. Realization of these solutions will require considerable applications-type R. & D. over the next few years.

Hearing on Storage and Disposal of Radioactive Waste before the Joint Comm. on Atomic Energy, 94th Cong., 1st Sess., 18 (1975). And in 1976, Elliot Richardson as Chairman of the Energy Resources Council^{9/} presented the timetable for the management of radioactive waste. This schedule called for NRC waste form and packaging regulations in 1978, ERDA site selection for underground excavation in 1978, and beginning of disposal facility operations in 1985. Hearings on Radioactive Waste Management before the Subcomm. on Envir. and Safety of the Joint Comm. on Atomic Energy, 94th Cong., 2d Sess., 20-21 (1976).

9/ The Energy Resources Council was created by sec. 108 of the Energy Reorganization Act of 1974, 42 U.S.C. §5818, to provide interim coordination of energy policy within the Federal Government and to advise the President on energy policy.

At the same time that Congress in general and the Joint Committee on Atomic Energy in particular were being kept informed of the status of radioactive waste disposal technology, they were also being told that new nuclear power reactors were being licensed and would continue to be licensed while radioactive waste disposal technology was being developed and implemented. As early as the 1959 hearings, supra note 8, at 2346-2350, the question of disposal of radioactive waste was discussed side-by-side with the projected growth in the number of operating reactors. At no time did the Joint Committee or Congress indicate in any way its belief that a "definitive finding of safety" for high-level radioactive waste disposal was a prerequisite to the continued licensing of nuclear power plants. Considering the fact that several amendments to the licensing provisions of the Atomic Energy Act were adopted during this period,^{10/} the absence of even a suggestion that the Commission's procedures

^{10/} See, e.g., Pub. Law 87-206 (75 Stat. 475) (1961) adding sec. 190, 42 U.S.C. §2240; Pub. Law 87-615 (76 Stat. 409) (1962) adding sec. 191, 42 U.S.C. §2241, amending sec. 189, 42 U.S.C. §2239; Pub. Law 88-489 (78 Stat. 602) (1964) amending sec. 184, 42 U.S.C. §2234; Pub. Law 91-560 (84 Stat. 1472) (1970) amending secs. 102-105, 42 U.S.C. §§2132-2135; Pub. Law 92-807 (86 Stat. 191) (1972) adding sec. 192, 42 U.S.C. §2242. It is interesting to note that Congress did not adopt suggestions by intervenor groups for a moratorium on nuclear power plants pending a resolution of "the waste storage problem." Hearings on Nuclear Powerplant Siting and Licensing before the Joint Comm. on Atomic Energy, 93d Cong., 2d Sess., 130, 567, 573 (1974).

were in violation of the Atomic Energy Act is strongly indicative that no such violation existed.

Nor is this Congressional understanding of the radioactive waste disposal issue surprising. Throughout the course of Congressional consideration, the consistent theme is that the waste disposal issue was "technically soluble", that there was adequate time to implement one of the alternative methodologies available, and that the need for a rapid implementation was social and political, rather than technical. It has also been recognized by Congress that the need to implement waste disposal for high-level radioactive wastes results from the wastes created by the Nation's military program, notwithstanding wastes which may be generated by commercial power reactors. See, e.g., Hearings on Nuclear Reactor Safety before the Joint Comm. on Atomic Energy, 93d Cong., 1st Sess., Part 1 184-85 (1973); Hearings on ERDA Authorizing Legislation Fiscal Year 1976 Before the Subcomm. on Legislation of the Joint Comm. on Atomic Energy, 94th Cong., 1st Sess., Part 2 1256, 1286-91 (1975); Oversight Hearings on Nuclear Energy -- Overview of the Major Issues Before the Subcomm. on Energy and the Environment of the House Comm. on Interior and Insular Affairs, 94th Cong., 1st Sess., Part 1 557-58 (1975). Thus, Congress recognizes that the need to assure safe disposal is a present necessity and

an existing commitment, regardless of the further licensing of nuclear power reactors.

IV. THE ENERGY REORGANIZATION ACT AND ITS LEGISLATIVE HISTORY SUPPORT THE COMMISSION REGULATIONS AND PRACTICE

NRDC's Petition asserts that the provisions of the Energy Reorganization Act of 1974 require the Commission to determine whether high-level radioactive wastes can be safely disposed of before granting reactor operating licenses. Petition at 2. The Petition purports to derive this from a partial quotation of that Act's declaration of purpose and from statements in the Senate Report that the NRC was to "upgrade the regulation of nuclear power" and that the Act was intended "to guarantee that the new Commission will have the strength and autonomy to carry out its awesome safety, health and environmental responsibilities." Petition at 5. Neither these meager references nor anything else in the Act or its legislative history support NRDC's position. To the contrary, even a cursory reading of this statute indicates that the existing Commission practice was understood and accepted.

NRDC states that

in creating the Nuclear Regulatory Commission, Congress specifically declared its intention in the Energy Reorganization Act ("ERA") "to advance the goals of restoring, protecting, and enhancing environmental quality, and to assure public health and safety". 42 U.S.C. §5801(a).

Petition at 5. NRDC would apparently ignore the rest of Congress' intentions set forth in the partially quoted section:

Congress hereby declares that the general welfare and the Common defense and security require effective action to develop, and increase the efficiency and reliability of use of, all energy sources to meet the needs of present and future generations, to increase the productivity of the national economy and strengthen its position in regard to international trade, to make the Nation self-sufficient in energy, to advance the goals of restoring, protecting, and enhancing environmental quality, and to assure public health and safety.

Energy Reorganization Act of 1974, sec. 2(a), 42 U.S.C. §5801(a). To focus solely on the last two phrases while neglecting the others is a disservice to Congressional intent.

Nor do the Congressional reports on the Energy Reorganization Act support NRDC's position. Congress recognized that the rate at which commercial high-level radioactive waste material is generated will increase.^{11/} The Conference Report noted that facilities for long-term storage of high-level radioactive wastes "are not now in existence but will be developed in the near future for long-term, possibly permanent, storage of high-level radioactive wastes, including wastes from the licensed sector." S. Rep. No. 93-1252, 93d Cong., 2d Sess., 33 (1974). Both of these statements are inconsistent with a requirement that future reactor operating licenses must include a "definitive finding of safety" on

^{11/} The act "anticipate[s] the time, probably in the 1980's when commercial nuclear power reactors will generate more high-level radioactive waste materials than reactors in the Government sector, including those used in the weapons programs". S.Rep. No. 93-980, 93d Cong., 2d Sess., 60 (1974).

high-level radioactive waste disposal.

Congress was obviously aware that high-level waste disposal facilities were yet to be licensed. Licensing of such facilities was seen as a future event. See, e.g., The Energy Reorganization Act of 1973: Hearings on H.R. 11510 before a Subcomm. of the House Comm. on Government Operations, 93d Cong., 1st Sess., 162-163 (1973); To Establish an Energy Research and Development Administration and a Nuclear Energy Commission: Hearings on S.2744 before the Subcomm. on Reorganization, etc. of the Senate Comm. on Government Operations, 93d Cong., 1st Sess., 45 (1973). Congress explicitly provided that the Commission shall have "licensing and related regulatory authority" over high-level radioactive waste storage facilities. Sec. 202(3) and (4), Energy Reorganization Act of 1974, 42 U.S.C. §5842. It would be highly unlikely that Congress, having directed the NRC to license waste disposal facilities not yet in existence, would have expected the kind of licensing findings to be made for these facilities to be a prerequisite to continued reactor licensing. If Congress had in mind the kind of moratorium which NRDC would impose through its Petition, it would not have put it into effect sub silentio.

V. THE COMMISSION HAS MADE THE REQUIRED FINDINGS ON THE FEASIBILITY OF SAFE DISPOSAL OF HIGH-LEVEL RADIOACTIVE WASTE

The Commission, on carrying out its National Environmental Policy Act ("NEPA") obligations, has made the requisite findings on the disposal of high-level radioactive waste,

as well as on other aspects of the nuclear fuel cycle. As interpreted by the courts, the Commission must include in its environmental analysis a consideration of radioactive waste disposal. Natural Resources Defense Council, Inc. v. Nuclear Regulatory Commission, ____ U.S.App.D.C. ____, ____ F.2d ____, Nos. 74-1385, 74-1586 (1976) (petitions for cert. pending). NRDC, in its discussion of waste disposal, relies on this NEPA decision as well as on Scientists' Institute for Public Information, Inc. v. Atomic Energy Commission, 156 U.S.App.D.C. 395, 481 F.2d 1079 (1973), another NEPA case. We need not quarrel here with the holding in Scientists' Institute for Public Information that "[t]he environmental problems attendant upon processing, transporting and storing these wastes. . . warrant the most searching scrutiny under NEPA." 481 F.2d at 1098 (emphasis added). It must be kept in mind, however, that the requirements of NEPA and those of the Atomic Energy Act are not necessarily identical. Union of Concerned Scientists v. Atomic Energy Commission, *supra*, 499 F.2d at 1078; *cf.* Citizens for Safe Power, Inc. v. Nuclear Regulatory Commission, 173 U.S.App.D.C. 317, 524 F.2d 1291 (1975).

In the NEPA context, the Commission has determined the feasibility of disposal of high-level radioactive wastes in the process of assigning an environmental impact to that

disposal.^{12/} This determination is incorporated in Table S-3 to 10 C.F.R. Part 51, the Commission's proposed amendment to Table S-3 set forth in 41 Fed. Reg. 45849 (1976), and in NUREG-0116 "Environmental Survey of the Reprocessing and Waste Management Portions of the LWR Fuel Cycle" (October 1976). Without a determination of the feasibility of waste disposal, it would obviously be impossible to specify the environmental impacts associated with disposal. As the Court held in Natural Resources Defense Council, Inc. v. Nuclear Regulatory Commission, slip op. at 10, the environmental consequences must be based on existing technology and those developments which can be extrapolated from it, not on "blind faith in technological progress." The finding of the feasibility of waste disposal finds ample support in ERDA's five volume study ERDA-76-43, "Alternatives for Managing Wastes from Reactors and Post-Fission Operations in the LWR Fuel Cycle." In this study, ERDA states:

The information contained in this document shows that all technologies needed to manage radioactive wastes from the back end of the commercial LWR fuel cycle are commercialized, available, or under development; there are no gaps.

ERDA-76-43, vol. 1, p. 5. To be sure, the site selection and detailed design of a waste disposal facility may not yet

^{12/} The Commission also determines the economic cost of disposal on a case-by-case basis as part of the cost-benefit analysis of each nuclear plant.

have been accomplished. Clearly, the Commission, Congress and the courts have recognized that uncertainties exist. Yet all have operated under the appropriate conclusion that safe disposal facilities will be built and operated.

VI. CONCLUSION

Safe disposal facilities must be built and operated. The issue of radioactive waste disposal cannot be made to go away by putting a halt to the issuance of new operating licenses. Existing quantities of high-level radioactive wastes, largely from this nation's military program, will not disappear if the commercial nuclear power program is halted by actions such as the NRDC petition. Nor will slowing or stopping the generation of additional high-level radioactive waste from the commercial program reduce the impetus for a timely implementation of a disposal technology. Present quantities of high-level waste, most of it already decades old, are themselves ample reason to install a safe disposal technology.^{13/} To that extent, the relief requested by NRDC is surplusage, and in this case mischievous surplusage since the underlying intent is surely to impose a moratorium on additional operating reactors. As shown above, the Petition should be rejected because it is premised on an erroneous legal theory. And, as shown above, the

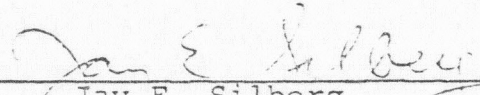
^{13/} One estimate indicates that by the year 2000, the commercial nuclear power program will have generated only one-tenth as much radioactive waste as has already been produced by the military program. Willrich, Radioactive Waste Management and Regulation, 2-17 (1976).

Commission has properly carried out its obligations under the Atomic Energy Act, NEPA, and the Energy Reorganization Act. Finally, as shown above, granting the Petition would serve no useful purpose. Rather, it would directly increase the magnitude of our existing energy problems, force a greater reliance on less dependable sources of energy, and impose higher costs on consumers of electricity. For all these reasons, we respectfully request that the Commission reject NRDC's Petition.

We appreciate the opportunity to submit these comments.

SHAW, PITTMAN, POTTS AND TROWBRIDGE

By



Jay E. Silberg

Dated: February 14, 1977

DOCKET NUMBER

PETITION RULE PRM-50-18

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Mr. Samuel J. Chilk
Secretary
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Attention: Docketing and Service Section
Natural Resources Defense Council
Petition for Rulemaking Regarding High Level
Radioactive Waste
(Docket No. PRM-50-18)

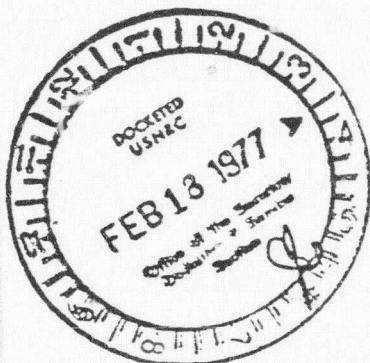
Dear Mr. Chilk:

Acknowledged by card 2/18/77

This letter, being filed at the Commission's invitation^{*/} responds to the Natural Resources Defense Council petition of November 8, 1976,^{**/} which requests that the

^{*/} These comments are being filed on behalf of the following companies, in their role as participants in the Commission's rulemaking proceeding on the Uranium Fuel Cycle (RM-50-3), on use of mixed oxide fuel (RM-50-5), or both: Baltimore Gas and Electric Co., Boston Edison Co., Consumers Power Co., Duke Power Co., GPU Service Corp., Long Island Lighting Co., Middle South Services, Inc., Northern States Power Co., Pacific Gas and Electric Co., Pennsylvania Power & Light Co., Philadelphia Electric Co., Public Service Electric and Gas Co., Rochester Gas and Electric Co., Southern California Edison Co., The Connecticut Light & Power Co., The Hartford Electric Light Co., The Northeast Nuclear Energy Co., Western Massachusetts Electric Co., Virginia Electric and Power Co., and Yankee Atomic Electric Co.

^{**/} The Commission assigned docket number PRM-50-18 to the petition and requested comments on it by February 14, 1977. 42 Fed. Reg. 2730 (January 13, 1977).



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Commission institute a generic rulemaking relative to the safety findings made by the Commission concerning material defined by NRDC as high level radioactive waste. Petitioner asks that the Commission not issue any further reactor operating licenses until completing the rulemaking. For the reasons which are summarized below, we believe that the rulemaking petition should be denied.

The petition commences with the Atomic Energy Act requirement, as a precondition to issuance of an operating license to a nuclear power reactor, that such operation be found to afford adequate protection to the public health and safety (42 U.S.C. § 2232). It then asserts that finally dispositive arrangements concerning radioactive waste products stemming directly or indirectly from such operation are not presently fully implemented. It concludes that the requisite safety findings relative to the safety of reactor operation thus cannot be made, and that further operating licenses should not be granted for power reactors, until the matter of wastes -- no matter how distantly removed from the reactor -- has been somehow resolved on a generic basis under Atomic Energy Act standards.

We believe that the petition's argument incorrectly glosses over the highly articulated structure of the Atomic Energy Act of 1954, as amended, and of its implementing regulations, which together provide for the separate licensing of individual facilities at each step of the fuel cycle, and for individualized consideration of the effects of each such

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for individualized consideration of the effects of each such facility at each such step. Consideration is given in each reactor operating license case to the adequacy of the applicant's plans for disposition of spent fuel rods -- the only point of tangency between the NRDC petition's definition of wastes and actual reactor operations.^{*/} The petition further overlooks the fact that Congress, in enacting the Energy Reorganization Act 42 U.S.C. §§ 5801 et seq. (Supp. V 1975) expressly recognized and implicitly accepted the technological and regulatory situation which the petition variously mischaracterizes as "the absence of an accepted [adequately safe, acceptably safe, accepted and approved] plan for disposing" of wastes (petition at 10, 11). In that Act, while not interrupting reactor licensing, Congress provided for NRC review of such future ERDA projects as "[f]acilities used primarily for the receipt and storage of high-level radioactive wastes" and "Retrievable Surface Storage Facilities and other facilities authorized for the express purpose of subsequent long-term storage of high-level radioactive waste generated by [ERDA]". Energy Reorganization Act § 202(3), (4), 42 U.S.C. § 5842(3), (4) (Supp. V 1975).

^{*/} Indeed, high level wastes as defined in the Commission's regulations, 10 CFR Part 50 Appendix F, are generated in the first instance only at reprocessing plants, not operating reactors. The only manner in which the petition is made directly applicable to reactor operation is by expansion of the term "high level wastes" to include the distinct matter of spent reactor fuel. Petition at 2 note 1/.

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NRDC's suggestion that the Commission should treat the matter of radioactive waste for all types of facilities in the nuclear fuel cycle by generic rulemaking rather than within the present regulatory framework is, at most, an appeal to agency discretion. An agency has broad discretion to resolve matters within its jurisdiction by either individual licensing cases or generic proceedings as it prefers. See NRDC et al. v. NRC et al. 539 F.2d 824,838 (2nd Cir. 1976) and cases cited thereat. Particularly here, where the Atomic Energy Act, Energy Reorganization Act and implementing regulations erect a structure contemplating both case-by-case licensing and the future conduct of relevant developmental work by other agencies, the Commission would be well within the bounds of sound administrative discretion in continuing to resolve matters of the type raised by NRDC--whatever their ultimate outcome on the merits--in individual licensing cases rather than through rulemaking.

Finally, it should be observed that the present petition, despite its reliance on various NRC documents associated with, and its comment on, other ongoing NRC proceedings (e.g., references to NUREG-0002 at 9, to RM-50-3 at 10 and Exhibit A) poses legal questions that are separate and distinct from the ones intrinsic to those other proceedings. We would urge the Commission, even though it may well, properly, draw on analyses prepared or used in connection with other proceedings, to continue

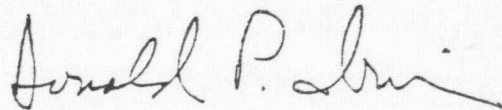
Mr. Samuel J. Chilk
February 14, 1977
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to treat and resolve the present petition as a separate
matter.

Very truly yours,

A handwritten signature in dark ink, appearing to read "Donald P. Irwin". The signature is fluid and cursive, with a long horizontal stroke at the end.

George C. Freeman, Jr.
Donald P. Irwin

Counsel to Baltimore Gas and
Electric Company, et al.

ONMSS ANALYSIS OF THE COMMISSION'S BASIS
FOR CONFIDENCE THAT HIGH LEVEL WASTES
CAN BE DISPOSED OF SAFELY

INTRODUCTION AND SUMMARY

The purpose of this paper is to identify the extent of the staff's confidence that high level radioactive wastes can be disposed of safely and to evaluate those factors which should be considered in order to make such a judgment. This paper is in response to the Commission's request made during Policy Session 77-13.

After reviewing available information, the staff has concluded that the Commission may base its confidence on the following:

- the technology for high level waste disposal is reasonably available,
- existing studies though not fully conclusive, support the feasibility and safety of geologic disposal,
- there is now a definitive, coordinated Federal program to develop and demonstrate a disposal system for high level radioactive wastes.

INFORMATIONAL ANALYSIS

To determine the basis for the Commission's confidence, two separate but key questions were posed: (1) can the wastes be disposed of safely, and (2) will the wastes be disposed of safely? The answer to the first rested heavily upon the technical consideration and to some extent on past performance, while the answer to the second rested more on the conditionally non-technical concerns (social, ethical, economic, institutional, etc.) that must be resolved.

The basis for a statement regarding the degree of confidence in safe disposal of nuclear wastes lies in an explanation of (1) the factors which might lead to a lack of confidence, (2) the factors which provide reason for confidence, and (3) a judgment regarding the threshold for confidence on each such factor.

The factors considered are:

1. The nature of wastes and the risks associated with their disposal,
2. Past performance and/or practices in waste disposal,
3. Actions by other jurisdictions regarding the need for demonstrated methods of waste disposal,
4. Recent analyses of the technologies for waste disposal and their safety and environmental impacts, and

5. Ongoing programs in the Federal agencies with regard to waste disposal.

This information is analyzed in summary form below and the extent of the staff's confidence is indicated. The references which were utilized in preparing this analysis are specified.

- I. Nature of Wastes and Associated Risks

- A. Quantity: There have been numerous projections of waste volumes by type for several scenarios of nuclear growth. Tables IV H-1, IV H-21 in GESMO and Table 3.4 (p. 3-16) in NUREG-0116 provide such information. (1-2) When measured by activity level, or curies, the amount of waste in temporary storage today as spent fuel and high level reprocessing wastes is substantial and growing rapidly. Measured on this basis, the current inventory will double in two to three years. The relevant consideration here is that the size of the current and anticipated inventory precludes its disposition into the biosphere and therefore permanent isolation is mandatory. Although current storage facilities are "acceptable as a temporary measure ... nuclear wastes remain a very serious potential health problem until isolated from the environment." (3)

- B. Expected Radionuclide Releases from Disposal Operations: The quantitative prediction of effluents from the operational phase of proposed disposal systems is within present calculational capabilities. These capabilities have been developed for existing

fuel cycle facilities and can be applied to the operations of future facilities as well. Limits on these effluents and their associated doses are specified by NRC regulations and would also be specified by forthcoming EPA standards. Effluents have been calculated in NUREG-0116 and found to be acceptable and well within present safety limits.

C. Long Term Risk from Radioactive Waste Disposal: The long-term risk (expressed as a time-dependent probability versus consequences) due to radioactive waste is a result of the possibility of a release of some fraction of the contained wastes to the human environment. The level of this risk, and its time-dependence, has not been completely assessed. A complete assessment would have to include creditable estimates of all mechanisms (man-made, natural and repository/waste induced) for breaching the waste repository. The estimates must be in terms of time-dependent probabilities for a particular degree of breachment. After breaching of the repository, the movement of waste materials through the geosphere to the biosphere must be calculated. When the waste material reaches the biosphere, their ultimate fate (accumulation in environmental receptors, environmental sink, recycling, etc.) must be calculated.

A complete, comprehensive analysis including all of the above consideration has not yet been performed. Nevertheless, there are a number of studies and partial analyses. (4-21) These

probably show the upper bounds of risk that would be obtained from a more complete analysis. Present, ongoing analyses have not identified any new concerns that would alter the levels of risk discussed below.

There are a number of potentially important phenomena that might affect the integrity of the repository and, once waste material is released, influence the level of consequences. Some of these phenomena have been, or can be, investigated to the extent that reasonably precise analytical models with supporting data bases can be developed and utilized. Other phenomena, such as climatic and demographic changes, and human actions, cannot be specified with any precision. Even with a great deal of investigation, we will not be able to specify these phenomena to any reasonable precision. Therefore, there will always be uncertainties associated with any risk estimate of waste disposal. Decisions affecting long-term disposal of the waste will have to be made with full awareness of these uncertainties.

In the following, the results of some of the partial analyses mentioned above are discussed. These analyses are separated into the areas of repository breaching and geospheric and environmental transport.

Repository Breaching: The most difficult part of a risk analysis is the estimation of the likelihood and degree of repository

breaching. Several researchers have avoided these difficulties by showing the relative hazards of the waste in the repository should it be breached. This has been done by calculating a "hazard index" for the wastes. The hazard index is defined as the quantity of water required to dilute the wastes, assuming them to be totally soluble, to maximum permissible concentration in drinking water. (6, 14-18) These analyses show that the waste repository possesses a significantly larger hazard than uranium ores during the first few thousand years after closure of the repository. Thereafter the hazard is less than that of uranium ores.

The hazard index is only a measure of potential hazard due to the existence of the waste and it does not take into account important phenomena such as different relative rates of migration of various radionuclides through soils and biospheric pathways.

Breaching of the repository by faulting, meteorite impact, and volcanism have been estimated. (4,7) There is agreement that the probability of these breaching mechanisms can be controlled by proper repository site selection and that it is not likely that the probability of breaching by these mechanisms would be larger than roughly 10^{-10} per repository per year. This point was made explicitly by the Advisory Committee on Reactor Safeguards, "The Committee has been unable to develop or postulate any event in such a facility that would be comparable to a Class 9 accident." (22)

Other less dramatic breaching events likely have higher probabilities of occurrence but result in a smaller quantity of waste being released from the repository. These events are subsidence, erosion, unplugged boreholes, etc.

Geospheric and Environmental Transport: The most likely consequence of breaching of the repository is the penetration of water into the repository and slow dissolution of the wastes. Given the penetration of water into the repository, analyses of the likely consequences have been performed. (5,7) These analyses have considered water penetration occurring at any time after repository closure and with a variable transport path length to a point of discharge to surface waters. As might be expected, the shorter the path length and time of initial dissolution of the waste, the larger the consequences (maximum radiation dose to an individual). This assumes that the presence of the waste materials in the water is not detected. The general conclusion from the analyses is that waste concentrations in the water, because of slow dissolution rates and long holdup times in the soil due to ion-exchange, would not be extremely large. The radiation doses to population that might arise would be fractions of natural background, or at most a few multiples of background for some individuals in unlikely cases.

II. Past Performance and/or Practices in Waste Disposal

In tracing the experience regarding the disposal of high level waste, a few historical events stand out. These have been

described in several documents and an outline will suffice here.(23)

- The basic conceptual framework for management of civilian HLW emerged from a report by the National Academy of Science's Committee on Waste Management in 1957. The Committee noted that "the most promising method of disposal of high-level waste at the present time seems to be in salt deposits." (24)
- Since large scale reprocessing of commercial fuel was not anticipated for many years, no sense of urgency was instilled into the disposal effort during the 1960's. However laboratory and field experiments were carried out relative to disposal in bedded salt (the medium of choice). (25)
- In 1970 and 1971 the nature of the AEC field experiment in Lyons, Kansas, changed twice--first from experiment to designated site, then from designated site to abandoned plans (too many technical difficulties with the site became apparent in the final stages of study and review). (26-28)
- During 1972 to 1975 an interim solution (the Retrievable Surface Storage Facility) was the core of the AEC program, and work on disposal almost ceased.

- In 1974 the environmental statement on the RSSF received such strong objections for its lack of attention to disposal that it was withdrawn in 1975 and the (ERDA) program was again directed toward primary emphasis on geologic disposal.
- In July 1976, an AEC (NRC) rule specifying uranium fuel cycle environmental impacts to be considered in the licensing of power reactors was remanded by the U.S. Court of Appeals, D.C. Circuit, because of deficiencies in the record regarding reprocessing and waste management.
(Vermont Yankee)*
- In October 1976, the President's Statement on Nuclear Energy called for an expanded effort in waste management that would result in having a HLW repository available by 1985.
- In December 1976, ERDA announced a massive program for an extensive nationwide search to identify several candidate sites for geologic disposal.

Today, geologic disposal is the major alternative being considered by the U.S. Government and has its counterpart in most other

*Public hearings on the Interim Rule resulting from the staff's reevaluation of the impacts from this portion of the fuel cycle will be scheduled in the near future.

countries. Alternatives to geologic disposal exist in principle, including space disposal and transmutation. Almost all agree that these technologies are beyond present capabilities, and many are not at all convinced that they can provide any incentives with regard to safety or environmental effects. While geologic media of great interest exist below the oceans and (perhaps) beneath the ice caps, logistics of working in these areas and a lack of detailed information make these beyond immediate use.

In the past, assurance that commercial high level wastes could be safely disposed of was based on expert engineering judgment which has been a part of the record in testimonies for many years. Meanwhile spent fuel has been stored safely on an interim basis for a number of years. The need for additional storage capacity for spent fuel as a result of the decision to delay reprocessing does not present any foreseeable health and safety and environmental impacts over the next few decades.

Perhaps because there have been no measurable or anticipated adverse public health effects from interim storage, there was also little sense of urgency in resolving the problem of permanent disposal. However, in the past year, public attention to the unfinished business of waste disposal has increased dramatically and the lack of a demonstrated waste disposal system has to some become a critical drawback to the continued use of nuclear power. This lack of a demonstrated system in the face of years of

insistence by scientific experts that it could be done, has resulted in public concern that perhaps there is no safe solution to the problem.

III. Other Jurisdictions

As the Commission is aware, high level waste disposal has become a critical issue within the States.* A number of state ballot initiatives were tied to the issue of waste disposal. While these all lost at the polls, the issue has been raised in a manner precisely like that of the NRDC petition. California has passed laws requiring a finding on the part of their Energy, Conservation and Development Commission that prior to siting further reactors in the State, the Federal agencies have "demonstrated"** and approved a safe disposal system. Recent court decisions have heightened public awareness of the issue. The decision in the Vermont Yankee case contributed to a perception

*The staff also considered actions in other countries where the issue of curtailing the expansion of nuclear power in light of the lack of demonstrated safe disposal systems is being faced. The new government of Sweden has ordered the industry to find a viable and safe disposal system in one year or the licensing for operation of additional nuclear plants will cease. A British report (of the Royal Commission on Environmental Pollution) concluding that solution of the waste disposal question must precede further expansion of the nuclear option for energy has received widespread publicity here and abroad. Recently, a German Court reached a similar conclusion in a case regarding a controversial power plant (further licensing is being held up pending the selection of a repository site). Conversely, Japan has decided to proceed on the basis of confidence in the developing technology. A number of other countries seem to be tacitly proceeding along a similar line. While these decisions do not have a direct bearing on the Commission's level of confidence, they could affect the public acceptability of a proposed disposal operation which could prevent its implementation.

**Demonstrated does not necessarily mean in operation.

that the high level waste question has been inadequately addressed. Since ERDA's announcement last December to expand its study of geologic formations for data on potential sites, bills have been introduced in a number of State legislatures (ten) banning high level disposal within the State. In Montana and Vermont the bills have been signed into law. In addition, a bill has been introduced in Congress (H.R. 5369) to provide for a referendum of the people on the question of locating a radioactive waste storage facility in a state.

The political force of these actions provides some measure of confidence that the Federal Government will continue on its present course for a solution. Counterbalancing this positive factor is the question of public acceptance of any specific disposal site as reflected in state laws banning high level waste disposal. The definition of an acceptable solution is dependent upon non-technological factors which have not been addressed in the traditional scientific-engineering approach. (29)

IV. Recent Analyses

Existing analyses from Federal agencies provide conclusions only regarding the availability of the technology and the expected (or reasonably anticipated) environmental impacts of the disposal system in normal operation. (30-33) Analyses are based on limited data and in at least one case (NUREG-0116) carefully note remaining uncertainties. Although existing analyses are inconclusive, they do tend toward confidence in the light of ongoing programs

which should resolve remaining questions.

Two of the documents dealing with the technologies for waste management--ERDA 76-43 and BNWL 1900--conclude that a number of alternatives are both technically feasible and ready for application. These documents do not, however, explicitly reach conclusions regarding the safety of such technologies.

Environmental analyses such as GESMO and NUREG-0116 predict little environmental impact (including radiological impacts) from waste disposal. However, either explicitly (in the case of NUREG-0116) or in the course of staff testimony in support of the document (in the case of GESMO), both have noted significant areas where analyses are still to be completed in order to reach conclusions based on detailed estimates of risk or impact. Still, it has been possible in both cases to reach a reasoned judgment that those analyses when complete will show additional impacts or risks which would not add significantly to those already calculated.

Also, there have been two independent analyses by individuals unallied to any agency or specific interest group, which have attempted quantitative analyses of the consequences of geological disposal. (34,35) Informal staff review of the Cohen analysis has shown that inadequacies noted in the early draft versions seem to have been corrected. The Lapp analysis is based on analogy with naturally occurring substances and has not as yet

been reviewed by the staff. Both conclude that geologic disposal is safe.

Perhaps most convincingly, independent analyses by outside review groups indicate confidence that the technology for permanent disposal is reasonably available. This confidence can be demonstrated by the following statements:

"It appears reasonable that one or more of the methods proposed for disposal of such wastes would be adequate to provide protection for the public and the environment from any potential long-range hazards." (22)

"We are convinced that nuclear wastes and plutonium can be disposed of permanently in a safe manner. If properly buried deep underground in geologically stable formations, there is little chance that these materials will reenter the environment in dangerous quantities. Even if material were somehow to escape eventually in larger quantities than seems possible, it would not constitute a major catastrophe, or even a major health risk, for future civilizations." (1, p.19)

"We expect that a repository site in bedded salt with suitable hydrogeology can be found, although an adequate data base does not yet exist to permit completion of the recommended analysis of groundwater flow and mass transport. We foresee no difficulty in obtaining the required data for a specific site and in completing such an analysis within the next few years." (36)

"We foresee no important technical barrier to the demonstration by 1985 of the technology for the solidification, encapsulation, transport and emplacement of commercial HLW into mined salt caverns. Retrievability would require improved design of protective sheathing and emplacement details to protect the canisters from corrosive attack by occluded brine in the salt and mechanical entrapment by creep deformation of the salt." (36)

"There are already substantial quantities of radioactive waste requiring secure disposal, but we are sufficiently hopeful that an acceptable solution will be found to this problem that we do not advocate halting the processes giving rise to the waste. Indeed, to do so might remove the sense of urgency that we believe to be required in seeking a solution." (37)

Analyses have shown us that technically there do not appear to be any serious reservations as to the feasibility of at least one waste disposal technology. The crucial remaining challenge that must be successfully confronted is to demonstrate this feasibility. For an assessment of the probability of achieving successful demonstration, the ongoing Federal program for waste management must be examined.

V. Current Federal Program

Recent changes in perception of the need for a solution to the waste management problem have been accompanied by a change in Federal commitment. There is now a definitive and coordinated Federal program to develop a disposal system for high level radioactive wastes. Central to this program is a vastly expanded ERDA effort to develop and implement a waste disposal system for commercial high level wastes. The ERDA budget for this effort increased from \$10 million in FY 1976 to \$69 million in FY 1977. Potential disposal methods have been investigated, at least to the extent where they could be accepted or rejected for technical reasons. The safety and environmental effects of these technologies will be addressed in a generic Environmental Impact Statement to be published by ERDA in late 1977 in draft form.

Through the National Waste Terminal Storage (NWTS) program, ERDA is expanding its study of deep underground formations within the United States to gather preliminary data on the suitability of

geologic disposal for safe terminal storage of commercial nuclear wastes. Geologic formations which are of high integrity, located in a seismically stable area and free of circulating groundwater will provide the barriers to assure that nuclear waste will not reach the biosphere in quantities that are harmful. Three generic categories of geologic formations are the basis of the studies: salt, argillaceous and crystalline rock formations.

Forty-five of the forty-eight mainland states are associated with major formations of the above generic categories. During the current fiscal year, the NWTS program will review the geologic records and conduct field investigations in thirteen of these states and conduct less intensive investigations in twenty-three other states. Given the large geographical area, the diverse rock types and the varying hydrological regimes, there is reason to believe that suitable sites can be identified. To date no site has been selected nor been judged suitable by either ERDA or the NRC.

The objective of the NWTS program is to select sites for six nuclear waste repositories in different geologic formations by 1986. The first two sites will be identified and selected by the end of 1978. While no specific decision has been made as to the geologic formation or location, it is estimated that the first two repositories will be in salt because more information is currently available on salt than any other rock type.

The program that is being developed would result in a design of a repository capable of receiving either processed waste or spent fuel elements. Site specific Environmental Impact Statements for each repository will be prepared.

On the basis of a number of reports (e.g., ERDA 75-43), all of the technology needed for geologic emplacement can be judged to be available. Conventional mining techniques are either directly adaptable to the present job, or can be slightly modified for the specific needs. Nothing new is anticipated in this regard. Handling of large radioactive objects (e.g., HLW cannisters or spent fuel bundles) has become routine in nuclear industry. Only the specific designs for the mine environment are required.

Preliminary conceptual designs (artists renderings plus basic dimensions) for a bedded salt repository have existed for several years. While actual detailed designs must await the development of site-specific properties of the disposal media and the overlying rock formations, world wide experience in mining salt gives confidence that no special problems will be inherent in designing a mine in salt to the specific requirements of the local geology.

The abolishment of the AEC and the formation of two separate agencies (ERDA and NRC) have also produced a significant change in the character of the Federal program for management of high level radioactive wastes. Prior to the reorganization, the AEC

had programmatic responsibility for developing, constructing and operating a Federal repository for the disposal of high level radioactive wastes. Since the AEC was exempt from its own licensing requirements, no provisions were made for independent licensing review of these operations. However, under the Energy Reorganization Act which created ERDA and NRC, NRC was given regulatory responsibility over ERDA facilities designed for "long-term storage" of high level radioactive wastes. This provides for the first time a full independent regulatory assessment for high level waste disposal and a mechanism for public participation in the decision making process.

In mid-1975 the NRC established a separate waste management unit to coordinate all NRC waste management activities. Principal initial efforts have been to (1) establish objective performance goals for management of nuclear wastes (2) develop a regulatory framework (regulation, standards and guides) which reflects these goals and (3) prepare licensing procedures (and assessment methodologies) needed to evaluate proposed waste management programs and strategies in light of this regulatory framework. Initial studies have been completed, tentative regulatory needs have been established and a program which will allow NRC to make timely licensing decisions is underway. The principal thrust of the program has been in the area of high level waste management with emphasis on having appropriate standards and regulations in place in time to provide guidance to ERDA in developing its HLW

repository program. Efforts are also underway in the areas of low level waste, uranium mill tailings, radioactive gases and decommissioning of nuclear facilities.

Significantly, there is one aspect of nuclear waste management that is operationally unique for the Commission. Simply stated, that aspect is that the NRC cannot forever discharge its health and safety responsibilities through the refusal of a license for the disposition of the wastes. For a reactor or other fuel cycle facility, the NRC discharges its health and safety responsibilities through the review process and can ultimately refuse a license if NRC criteria are not likely to be met. For a waste disposal system, a refusal merely postpones the ultimate discharge of these responsibilities.

The relevant issues at this point are (1) whether the recent momentum which has been generated in the Federal program can be maintained, and (2) whether this program will be accompanied by the strong national commitment that is likely to be necessary for successful implementation. Confidence generated by the momentum and thrust of the ERDA program must now be considered in the context of the recently changes policy regarding reprocessing and the extended storage of spent fuel. It is our understanding that the Executive Branch will not alter the goal of having a high level waste repository available for demonstration

and that this will be reflected in the priorities placed on the program's structure, direction and budget within the proposed Department of Energy. Such assurance has been provided recently by the Acting Assistant Administrator for Nuclear Energy in ERDA, "...We still believe that this objective [operation of two repositories by 1985] must be met to demonstrate a permanent solution to waste management ..."(38) The NRC staff will periodically review the ERDA program and advise the Commission as to its progress.

The staff has also considered those actions that could influence the level of commitment needed for the obtainment of goals. Examples of these actions are the increasing number of State and Federal hearings devoted to waste management, the GAO review of Federal waste management programs and the interest of the Executive Branch as seen in the commissioning of a review by the Science Advisor to the President and the decision by the President to conduct a thorough review of ERDA's waste management program.

These activities, of course, go beyond merely indicating that there is interest and concern at all levels for finding a solution to the waste management problem. The reviews completed to date stress confidence in technical feasibility while acknowledging there could be serious institutional and social obstacles to timely and acceptable implementation. We expect that the concerns

raised as the result of these reviews will be faced and remedied.

CONCLUSION

On the basis of technical considerations which indicate that the technology is reasonably available for the geologic disposal of high level waste, the Commission can respond positively to the question, "Can the wastes be disposed of safely?"

However, the degree of confidence the Commission can have regarding whether or not the wastes will be disposed of safely is more limited. Regardless of the technical feasibility of disposal, selection of disposal sites will be highly controversial and there will almost certainly be a problem with public acceptance. In addition, the current interest in an interim storage concept for spent fuel and postponement of reprocessing and the breeder could result in a decreased sense of urgency in demonstrating a system for final disposal at the same time that quantities of waste nuclides are rapidly increasing. Thus far, indications are that the present high priority of the program will continue. On balance, therefore, the staff believes that:

1. Because the quantities of wastes being generated in the commercial industry are such that they cannot be released to the biosphere, it is necessary that a safe and environmentally acceptable facility be available for disposal of high level radioactive wastes. The available information regarding high level waste disposal suggests optimism in its

technical feasibility and the existence of geologically acceptable sites. Pending detailed review, it is likely that the wastes can be disposed of in a safe manner.

2. Pending this review, our confidence in the ultimate safety of permanent disposal is based on existing knowledge of the current technology and associated risks and the momentum and size of the Federal program.

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2.1 Reprocessing

Spent fuel from uranium-fueled light water reactors (LWRs) contains considerable fissionable material--both uranium and plutonium--which may be recovered for use in new fuel. Reprocessing is an operation in the fuel cycle wherein spent fuel is processed to separate the usable uranium and plutonium from unwanted fission products (wastes) (see Sec. 4.1).

The Purex solvent extraction process has been the chosen method of fuel reprocessing for many years, and is the choice for evaluation here. The model was selected from the many plant variations possible and is the one used in GESMO.

In the fuel reprocessing plant (FRP) the spent fuel is chopped into pieces, the fuel is dissolved by nitric acid, and the resulting uranium, plutonium, and waste streams are converted to suitable physical and chemical forms either for disposal or for shipment and further use in the fuel cycle.

Variations on this technology have been in use by the AEC (now ERDA) and the industry for over 20 years. Environmental impacts derived from that experience but based on the model plant used in GESMO are listed in Tables 2.1 and 2.10 below, normalized to the contribution of a single RRY. Land commitments and resource use are typical of any industrial facility. Nonradiological effluents are small, and less than in comparable (e.g., chemical and petrochemical) industries. The primary radiological effluents are gaseous fission products and activation products from the spent fuel (krypton-85, iodine-131,

carbon-14, etc.). These are the major effluents from the entire nuclear fuel cycle, and their assumed release gives a conservative estimate of total population dose commitment.* Total whole-body dose commitments to the world population from the reprocessing demanded by a single LWR in a year is about 600 person-rem for uranium-only recycle. The dose to the same population from natural background is about 300 million person-rem per year.

The literature regarding the environmental impacts of both normal and abnormal reprocessing operations is well developed. Some uncertainty remains regarding details of the design and operation of the plutonium conversion and HLW solidification facilities (see Sec. 4.2.2), but adequate experience at smaller scales is available to provide reasonable estimates of impacts at reprocessing plant sites.

2.2 High-Level Wastes

High-level wastes (HLW) produced at the reprocessing plant contain the majority of the highly radioactive fission products from the spent fuel. These wastes (see Ch. 3 and Sec. 4.2) require a system for their management which provides radiation shielding, protection against release, and a means of heat dissipation.

The conceptual system for HLW management includes the

*Pending EPA standards may further limit these releases.

the following steps: (1) short-term storage as liquid in tanks; (2) solidification; (3) short-term storage as a solid; (4) shipment to a repository; and (5) disposal. Provision for longer-term interim storage before disposal could be necessary and is included in our discussion.

APPENDIX A

NUCLIDES OF INTEREST

Summary of Activities (Ci/MTU) for Radionuclides of Interest as a
Function of Post-Irradiation Time

(NOTE: Nuclides whose contribution to the specific activity of the
than 0.001 Ci/MTU at a post-irradiation time of 150 days are less
)

Power = 30MW; Burnup = 33,000 MWD; Flux = 2.92×10^{13} n/cm²-sec

Z	Radionuclide	Half-life*	Discharge**	Curies/Metric Ton Uranium		
				160 days**	1 year**	10 years**
1	H-3	12.26y	7.09E02	6.91E02	6.7E02	4.03E02
4	Be-10	2.7×10^6 y	-	-	-	-
6	C-14	5770y	-	-	-	-
20	Ca-41	1.1×10^5 y	-	-	-	-
27	Co-60	5.27y	-	-	-	-
28	Ni-59	8×10^4 y	-	-	-	-
34	Se-79	7×10^4 y	3.98E-01	3.98E-01	3.98E-01	3.98E-01
36	Kr-85	10.4y	1.13E04	1.10E04	1.06E04	5.96E03
37	Rb-87	4.7×10^{10} y	-	-	-	-
38	SR-89	50.4d	7.18E05	8.51E04	5.53E03	5.15E-16
	SR-90	28y	7.76E04	7.68E04	7.57E04	6.07E04
39	Y-90	64.2h	8.07E04	7.68E04	7.58E04	6.07E04
	Y-91	57.5d	9.38E05	1.43E05	1.28E04	1.89E-13
40	Zr-93	9.5×10^5 y	1.89E00	1.89E00	1.89E00	1.89E00
	Zr-95	65d	1.37E06	2.49E05	2.80E04	1.67E-11
41	Nb-93m	3.7y	1.45E-01	1.83E-01	2.31E-01	8.40E-01
	Nb-95	35d	1.38E06	4.73E05	5.95E04	3.61E-11
42	Mo-93	10^4 y	-	-	-	-
43	Tc-99	2.1×10^5 y	1.43E01	1.43E01	1.43E01	1.43E01
44	Ru-103	40d	1.22E06	7.41E04	2.05E03	2.09E-22
	Ru-106	1.0y	5.45E05	4.03E05	2.73E05	5.50E02
46	Pd-107	7×10^6 y	1.10E-01	1.10E-01	1.10E-01	1.10E-01
47	Ag-110m	249d	3.68E03	2.37E03	1.35E03	1.66E-01
50	Sn-126	10^5 y	5.46E-01	5.46E-01	5.46E-01	5.46E-01
51	Sb-125	2.0y	8.7E03	7.89E03	6.83E03	6.78E02
52	Te-127m	105d	1.54E04	5.77E03	1.57E03	1.30E-06
	Te-129	67.3m	3.37E05	1.42E03	2.17E01	0.0
53	I-129	1.72×10^7 y	3.71E-02	3.74E-02	3.74E-02	3.74E-02
	I-131	8.05d	8.61E05	9.23E-01	1.99E-08	0.0
55	Cs-134	2.19y	2.46E05	2.12E05	1.76E05	8.38E03
	Cs-135	2.0×10^6 y	2.86E-01	2.86E-01	2.86E-01	2.86E-01
	Cs-137	30y	1.08E05	1.07E05	1.05E05	8.56E04

- The public will have the opportunity to participate in the decisional process of the Commission not only by submitting written comments on the draft environmental statement and proposed rules but also by participating in the public hearings to be held on the final statement and on any implementing rules. The legislative-type hearings will be started as soon as practicable after issuance of the nonsafeguards portion of the final statement. These legislative-type hearings may be followed by adjudicatory type hearings on particular issues if need for further hearings is demonstrated to the Commission.

The final GESMO is being published in two parts--a final evaluation of the health, safety, and environmental impacts of plutonium recycle (including a cost-benefit balancing), and a supplement containing the final evaluation of safeguards (including the final cost-benefit balancing). This document is the health, safety, and environmental portion of the final GESMO. Proposed rules relating to the possible widescale use of mixed oxide fuel will be published at about the same time as final portions of the environmental statement are issued.

1.1.2 Fuel Cycle Options for Light Water Reactors

The fuel currently used in LWR's is low enriched (about 3%) uranium dioxide (UO_2). The heat energy produced during operation of newly fueled LWR's comes basically from the

fissioning of the uranium-235 atoms in the fuel. As the reactor operates, atoms of fissile plutonium, Pu_f (i.e., plutonium-239 and plutonium-241), are produced by transmutation of uranium-238 atoms. The fissioning of some plutonium atoms contributes to the energy produced by the reactor.

When fuel can no longer sustain a chain reaction at economic power levels, it is considered to be spent and removed from the reactor. At that point, the fuel still contains fissile isotopes (about 6 grams fissile plutonium and about 8 grams of uranium-235 per kilogram of uranium) and about 98% of the uranium-238 originally charged. These can be recovered from the spent LWR fuel by chemical treatment in a reprocessing plant. It is the potential recovery of fissile isotopes from spent fuel that gives rise to three recycle options for LWR's. If the spent fuel is disposed of without reprocessing, the fuel cycle option is referred to as the "no recycle" option. If spent fuel is reprocessed and the recovered uranium is recycled with plutonium being disposed of as a waste, the fuel cycle option is called "uranium recycle." In the third recycle option, the "uranium and plutonium recycle" option, both uranium and plutonium are recovered by reprocessing and recycled as fuel to LWR's.

Plutonium recovered by reprocessing spent fuel is combined with uranium having a lower uranium-235 content than that of new low enriched uranium fuel to make an equivalent LWR reactor fuel. Thus, a substitution of recovered plutonium is

made for some of the uranium-235. Such fuel is called plutonium-uranium mixed oxide or simply mixed oxide (MOX) fuel. The diluent uranium used in mixed oxide fuel has been assumed to be natural uranium throughout GESMO. One special case, that of blending plutonium with low enriched uranium in every fuel rod, called dilute plutonium recycle, has been considered in CHAPTER IV, Section L.

external radiation, cosmic rays interact with atmospheric components to form radionuclides that contribute to internal radiation exposure from natural sources.

Internal irradiation from natural sources is contributed by tritium, ^{14}C formed by cosmic ray interactions and the primordial radionuclides ^{40}K and ^{87}Rb , and the three radioactive decay series headed by ^{238}U , ^{235}U and ^{232}Th .

Doses from internally deposited naturally occurring radionuclides average 18 mrem/yr gonadal dose.^{2,3} Potassium-40 contributes a major portion of this dose and the content in the body varies with diet and location. Other radionuclides contributing to the dose also vary with location. The air and diet contents of ^{238}U , ^{228}Ra , ^{226}Ra , ^{222}Rn , ^{220}Rn , ^{210}Pb and ^{210}Po are dependent on the type of geologic formations in an area.

In GESMO, 100 mrem/yr whole body dose, essentially as reported in BEIR, is used as the typical value for the radiation dose from natural sources.

1.2 Units of Radiation Dose

Throughout this document the word "dose" is usually used as a shortened term for dose equivalents which have units of rem. More commonly, the magnitude of radiation dose equivalents encountered have units of mrem (one thousandth of a rem). Other units that may be encountered are the Roentgen and rad. The definition of the Roentgen specifically limits its application to exposure to gamma or X-radiation. The rad is a measure

of the energy absorbed in a substance by any of the ionizing radiations. It is only a few percent greater than the Roentgen, being rounded to the value of 100 ergs of energy absorbed per gram of absorbing material. For the same rad dose, alpha and neutron radiations are generally more effective in producing damage in biological systems. The difference in biological response to various radiations is calculated from the ratio of the rads of neutrons or alpha particles to the rads of gamma or X-rays for the same biological response. This ratio, for human dosimetry purposes, is the quality factor (Q). A distribution factor is considered for dose distribution in tissue. The product of rads, distribution factor and quality factor for a given radiation type is the amount of dose equivalents in rem. Once the doses from several different radiations are expressed in rem, the total dose equivalents to an organ or whole body can be obtained by summation.

The term "man-rem" is derived from the rem and in this report is called "person-rem." It is the summation of all the individual rem doses in a given population. It was devised to assess the exposure of a population for hypothetical evaluations and comparisons of the public health impact of radiological releases. Its validity is contingent upon the premise that the probability (or risk) of a biological effect from radiation is proportionate to the rem dose, regardless of its magnitude or rate of delivery. In this report, the term person-rem is also applied to the summation of doses to specific organs in a population. The product of the person-rem for a given organ or

or system in a population and a risk estimator results in an estimate of the ill

Table IV J(A)-1

DOSE FACTORS THAT DIFFER FROM THOSE OF ICRP 2 AND 6

Isotope	Organ of Reference	Maximum Permissible Concentrations	
		Water ($\mu\text{Ci}/\text{cm}^3$)	Air ($\mu\text{Ci}/\text{cm}^3$)
^{89}Sr	Bone	3.4×10^{-4}	2.9×10^{-8}
^{90}Sr	Total Body	2.7×10^{-3}	2.2×10^{-7}
	Bone	3.3×10^{-6}	1.7×10^{-10}
^{132}Te	Total Body	2.7×10^{-5}	2.3×10^{-9}
^{226}Ra	Thyroid	1.6×10^{-4}	2.1×10^{-8}
	Bone	1.3×10^{-6}	1.1×10^{-10}
INREM DOSE FACTORS ⁴			
^{243m}Pa	Total Body	43	1.9×10^{-6}
	Bone	54	2.5×10^{-5}
	Liver	120	5.0×10^{-6}
	Kidney	31	
	Lung		3.2×10^{-7}
^{234}Pa	Total Body	193	8.5×10^{-6}
	Bone	236	1.1×10^{-5}
	Liver	525	2.2×10^{-5}
	Kidney	139	6.1×10^{-6}
	Lung		1.4×10^{-6}
^{237}U	Total Body	0.57	2.4×10^{-6}
	Bone	1.3	5.4×10^{-6}
	Kidney	0.13	5.8×10^{-7}
	Lung		2.9×10^{-7}
UPDATED IODINE MODELS ^{1,2}			
^{129}I	Total Body	5.8×10^{-4}	8.3×10^{-3}
^{131}I	Thyroid	5.2×10^{-6}	7.5×10^{-10}
	Total Body	1.8×10^{-3}	2.6×10^{-7}
^{133}I	Thyroid	2.2×10^{-5}	3.1×10^{-9}
	Total Body	8.1×10^{-3}	1.2×10^{-6}
	Thyroid	8.6×10^{-5}	1.2×10^{-8}

INTRODUCTION
AND EXECUTIVE SUMMARY

This document describes technologies for managing radioactive wastes from commercial nuclear power. It is directed specifically at wastes associated with what is known as the "back end of the LWR fuel cycle," i.e., activities related to handling of spent fuel after it is removed from light-water cooled reactors (LWRs). The LWRs are currently the predominant reactor type in the commercial U.S. nuclear power industry.

The document characterizes the technologies and classifies their state of availability. It is not a decision or program document. It is strictly a baseline or reference document, technical in nature, and designed to serve as a sourcebook of information on the technologies of radioactive waste management. It is a bridge between past and future activities to develop technology for managing radioactive wastes; i.e., it describes the current status of technology and provides a basis for future action. It is assumed that the technologies to be adopted must be operable within the applicable radiation safety regulations.

ORIGINS AND FUNCTIONS OF THE DOCUMENT

This document is an outgrowth of a need for technical alternatives in preparation of an environmental statement and a request from the Joint Committee on Atomic Energy for a comprehensive report on options for managing radioactive wastes. It is also a step in ERDA strategy for fulfilling its responsibilities concerning development of commercial radioactive waste

managment technology. This document is responsive to the JCAE request for a discussion of options; it simultaneously provides baseline information and data for formulation of ERDA program plans and preparation of environmental impact statements. Other documents will address R&D plans; still others will address environmental impacts.

The basic purpose of this document is to provide government, industry, and the public a convenient, comprehensive and non-evaluative description of the technologies to be considered in actions such as preparation of environmental impact statements or selection of ERDA programs concerned with managing wastes from the back end of the fuel commercial LWR fuel cycle. A document of this type is needed because there are in fact numerous alternative technologies for each aspect of radioactive waste management. This compilation of information helps assure that all alternatives are considered, and that all participants in actions to make selections have a common information base. To preserve its role as a source document, this report makes no recommendations, makes no comparative assessments

2.3 WASTES FROM SPENT FUEL STORAGE FACILITIES

A spent fuel storage facility (pool) offers a number of services, including storage, cooling (usually by transfer of heat to the environment through a secondary cooling system and heat exchanger, e.g., an evaporative cooling tower), shielding, inspection, and control of radioactive materials released from both intact and failed fuel.^(1,2) Pools will be a source of both wet and dry solid wastes that will require shipping, storage, and associated management operations. These wastes consist mainly of the byproducts of operations used to remove radioactive materials introduced into the pool water by both intact and failed fuel.

Pools are presently located at Federal sites including the Savannah River Plant, the Idaho National Engineering Laboratory, and the Hanford Plant. These pools are associated with both government-owned reactors and fuel reprocessing plants. Other pools are located at nuclear power stations and commercial fuel reprocessing plants. Although commercial plants are not reprocessing fuel at present, the fuel pools at both the Nuclear Fuel Services (NFS) Plant* and Midwest Fuel Reprocessing Plant (MFRP)** are already used for storage of spent fuel assemblies, and the pool at Barnwell Nuclear Fuels Plant (BNFP)+

*West Valley, NY.

** General Electric Co., Morris, IL.

+Allied-General Nuclear Services, Barnwell, SC.

is expected to be put into service before reprocessing begins.⁽³⁾ In addition to the above locations, independent pools, not associated with any other nuclear facility, have been proposed to alleviate the lack of storage space for fuel presently being discharged from operating nuclear power stations, but for which storage capacity is rapidly diminishing. Several design studies are under way in an attempt to substantially increase the capacity of existing water basins.

The following sections discuss the characteristics of spent fuel, the operations of fuel pools, and finally the wastes emerging from these operations.

2.3.1 Description of Spent Fuel

Light-water reactor fuel assemblies⁺⁺ are composite units made of fuel elements⁺⁺ in a geometric cluster and held together by end pieces and a number of element spacers. BWR and PWR fuel assemblies differ significantly, but the basic component of each is the fuel element. A fuel element of either type is a long section of metal tubing filled with ceramic pellets or uranium dioxide or mixed uranium-plutonium dioxide and closed at both ends (see Figure 2.11). The BWR⁽⁴⁾ cladding tube is typically

⁺⁺"Fuel Assembly: A grouping of fuel elements which is not taken apart during the charging and discharging of a reactor core--Fuel Element, The smallest structurally discrete part of a reactor or fuel assembly which has nuclear fuel as its principal constituent." (7)

larger (~1.4-cm diam) and the finished element longer (~400 cm) than the PWR element. A typical fuel loading is ~3 kg of heavy metal in the oxide form per BWR fuel element. A PWR fuel element,⁽⁵⁾ on the other hand, has cladding with a 1-cm diam and a 380-cm length. A typical PWR fuel loading is ~2 kg of heavy metal per element.

Differences between completed BWR and PWR fuel assemblies are even more noticeable. In the BWR assembly (Figure 2.12), the fuel elements are arranged in a 7- x 7-element square array, but advanced fuels are to contain 8 x 8 arrays of 1.25-cm diam elements.^(4,6) The total fuel-loading is ~200 kg of heavy metal for an average 64-element BWR fuel assembly. The individual elements are secured by upper and lower tie-plates and spacer-grids at intervals along the element cluster. The entire assembly is covered by a thin Zircolay sheet-metal box called a fuel channel. The fuel channel is normally reused following withdrawal of an assembly. The total weight of a completed BWR fuel assembly is typically ~280 kg (excluding fuel channel). It has a 14- x 14-cm cross section and is 4.5 m long.

The PWR assembly (Figure 2.13) contains 264 fuel elements in a square (17 x 17) array of locations, some of which are occupied by reactivity-control rods,* instrumentation,* and burnable-poison elements.^(5,9) An average fuel loading for a

* Control rods and in-core instrumentation are not part of a PWR assembly and are removed from the array prior to reactor discharge.

complete PWR assembly is ~460 kg of heavy metal. A PWR assembly has no cover or coolant channel, being secured by top and bottom nozzle fixtures and spring-clip grids spaced along the length of the element cluster. A completed PWR fuel assembly weighs ~670 kg, has a cross section of 22 x 22 cm, and is about 4 m long.

2.3.2 Properties of Spent Fuel

For purposes of describing compositions of waste streams, the physical differences in BWR and PWR fuel assemblies and the imbalance of numbers of the two types of reactors in the industry are synthesized into hypothetical "reference LWR" fuel assembly. Table 2.2 characterizes the reference assembly. Table 2.3 details the chemical composition. The oxide fuel would be contained in a square array with 2.57 kg of heavy metal per element. Total weight of this reference assembly is set at 454 kg. The reference LWR fuel assembly contains fuel-cladding tubes that are made of Zircolay with Zircolay end plugs. Top and bottom assembly tie-plates or nozzle fixtures will be fabricated from type 304 stainless steel. Element-spacing fixtures will be of Inconel. The fuel pellets are UO_2 or $(\text{U}, \text{Pu})\text{O}_2$.

on the reference LWR fuel assembly containing 311.4 kg of heavy metal, 147 spent-fuel assemblies will be discharged for each 1000 MWe-year. A 1500-MTHM/year fuel reprocessing plant will process about 4800 of the reference assemblies each year, or 16 assemblies per day for 300 days. This rate is equal to fuel output from 33,000 MWe-year power generation by LWRs. Table 2.5 gives the weight distributions of the reference LWR assembly at various appearance rates.

2.3.4 Characteristics and Operations of Reactor Pools

A typical ~1000 MWe reactor pool can store as much as 1 2/3 reactor cores, i.e., about 100 to 250 MTHM of fuel.** During storage, much of the activity associated with short-lived isotopes will decay. The presence of short-lived activity distinguishes reactor pools from the pools both at fuel reprocessing plants and independent locations. At some reactors, assemblies are transferred from core positions to storage in the pool via a canal that joins the core and the pool. Thus, in this transfer, primary coolant mixes with pool water and the pool water can become contaminated. Radioactivity can be introduced into a reactor pool from mixing with primary coolant, from leaching of fuel from assemblies with failed cladding, and from shedding of deposits from the surfaces of assemblies.

** PWR core, 89 MTHM; BWR core, 138 MTHM. (4,5)

After irradiation at 35/MW/MTHM specific power and 25,000 MWd/MTHM burnup, in the core of a LWR, a spent-fuel assembly will have a total thermal power of 640 kilowatts (KW). After 120 days cooling the heat generation rate has decayed to 8.4 KW per assembly. These data are shown in Table 2.4. A detailed list of fission products, actinide elements, and metallic construction elements, together with the anticipated radiations for various cooling times is also shown in Table 2.4. The spent-fuel assemblies will have a beta-gamma radiation dose rate at discharge of $>10^6$ Roentgen/hour (R/hr) at the most radioactive surface.

For the purposes of this document, it is assumed that the LWR spent-fuel assemblies contain no leaking and/or ruptured fuel elements. Thus, it is assumed that, except for emission of heat and radioactivity, the assemblies are physically unaltered from their fabricated conditions. It is recognized that a modest fraction of assemblies will contain leaking elements and that these require special handling. This impact on the overall waste management processes described in these sections is assumed to be small.

2.3.3 Quantities of Spent Fuel

It is assumed that a LWR will generate 45.6 MTHM of spent fuel in the production of 1000 MWe-year of power.* Based

* Based on 25,000 MWd/MTHM burnup as currently apparent in spent fuel and an efficiency of 0.32 MWe/MWth.

17.0 INTERIM STORAGE OF SPENT FUEL ELEMENTS

17.1 SUMMARY

In the uranium fuel cycle initially conceived for light water reactors (LWR), spent fuel was to be discharged from the reactors and then allowed to cool (at the reactor sites) for five months. This cooling period would allow short-lived radioactive isotopes to decay and thereby reduce the heat generated. After the cooling period, the fuel was to be shipped to a chemical reprocessing plant, which would recover uranium and plutonium. Accordingly, existing storage facilities at LWR sites were designed for only short-term storage of spent fuel. More recently, however, spent fuel has been recognized as a possible waste form⁽¹⁾ suitable for interim storage and even ultimate disposal.*

Alternatives for managing spent fuel include:

- ° Storage of unpackaged fuel in water-cooled basins or air-cooled vaults where reprocessing is not expected to be delayed more than 10 to 20 years.
- ° Storage of packaged spent fuel in water-cooled basins, air-cooled vaults, concrete surface silos, geologic formations, or near-surface heat sinks where reprocessing is expected to be delayed beyond 10 to 20 years.

* Whether or not respect for the principle of conserving energy resources would require the U.S. government to reprocess spent fuel, even though the original owner had declared it to be waste, is beyond the scope of this report.

Table 1 compares the storage alternatives. Alternatives not considered include fuel dissolution and subsequent solidification without separation of uranium and plutonium.

The fuel cladding is the initial barrier for confinement of fuel core material for all modes of spent fuel storage. The cladding withstands a far more-severe environment in the reactor than it would encounter in a storage facility although for a shorter period of time. In concept, a storage facility is designed to protect the fuel cladding against mechanical, chemical, or thermal damage; the storage facility provides for a safe, subcritical arrangement for fuel assemblies and adequate shielding under normal operating conditions or during extreme natural phenomena.⁽²⁾ Additional confinement is provided by cleanup of the effluent coolant streams when bare fuel is stored, and/or by the container if the fuel has been packaged.

Water-cooled storage of either bare spent fuel or packaged fuel would normally be in a near-surface facility with water-filled cells of heavily reinforced concrete lined with stainless steel. Auxiliary equipment would cool the water and maintain water quality. The technology of water basin

radiation. The fuel would likely be packaged at central storage facilities rather than at reactor sites, according to studies⁽³⁾ that show the economic advantages of fuel reprocessing in central processing stations. Also, shipping cask volumes and therefore shipping cask weights can be reduced by shipping unpackaged rather than packaged assemblies.

17.2 STORAGE OF UNPACKAGED SPENT FUEL

17.2.1 Storage in Water-Cooled Basins

17.2.1.1 Summary

A facility for water-cooled storage of unpackaged (as-discharged) spent fuel is shown on the process summary sheet and would consist of near-surface, water-filled cells of heavily reinforced concrete lined with stainless steel and having auxiliary equipment to cool and control the quality of the water. In addition to serving as a heat transfer medium, water provides radiation shielding, partial containment for escaping radioactivity, and a heat sink under some accident conditions. Also, water allows visual observation of the stored fuel. The technology of water basin storage of bare spent fuel is well developed and demonstrated by about 30 years of experience (sequential storage) at reactor sites and fuel reprocessing plants.

17.2.1.2 Facility Description

Spent fuel from LWR's is currently stored in water-cooled basins. Most of these basins are at reactor sites and

designed to hold from 50 to 150 MT of irradiated fuel.⁽⁴⁾ A recently designed facility at a reprocessing plant has a capacity for 400 MT of spent fuel.⁽⁵⁾

A concept for a separate facility (i.e., not located at a reactor or fuel reprocessing site) for storage of spent fuel suggests the use of modular basins with each basin having a capacity for about 500 MT of spent fuel. The facility (Figure 1) is designed to receive, handle, decontaminate, and reship spent fuel casks; to remove irradiated fuel from casks; and to place the fuel in a storage basin. The basin, constructed of heavily reinforced concrete and lined with stainless steel, provides biological shielding, protection from natural phenomena, and secondary confinement of radioactivity. Fuel assemblies are stored in underwater racks and are so spaced as to prevent formation of critical arrays. A process building covers the basins to protect operating personnel, cranes, and other support equipment from the weather.

The basin ventilation system maintains the concentrations of radioactive gaseous contaminants at as low a level as practical.^(2,6) Both HEPA and carbon filters (or silver zeolite absorbers) can remove particulates and iodine from ventilating air. Demisters may be required to remove entrained water from the air. Basins at a fuel reprocessing site can share gas reprocessing systems with the reprocessing plant. Treatment of off-gases to remove tritium and noble gases would be more feasible with this facility than with most others because of the low volume of air vented.

The facility buildings would be equipped with radiation monitoring devices around the fuel handling equipment and with continuous off-gas monitors in the basin area⁽⁸⁾ to detect and report abnormal radioactivity.

The design of water-cooled basins includes engineered safety features and automated protective systems and dictates operating procedures. For all practical purposes, the design minimizes the probability of a serious accident that would release radioactive contaminants.

17.2.1.7 Maintenance

Maintenance practices and procedures for fuel storage facilities are well established. Water treatment and air ventilation systems require routine maintenance to ensure proper operation of pumps and fans. Solid contaminated wastes (Section 3.0) from basin operation, including demineralizer resins, filters, tools, protective clothing, and miscellaneous

trash could be compacted and packed in drums for shipping to a land-burial site.

17.2.1.8 Status of Technology

17.2.1.8.1 Current. The technology of water basin storage of spent fuel is well developed and demonstrated by approximately 30 years experience at reactor sites and fuel reprocessing plants. In new installations, the fuel assembly spacing probably would be determined by economics, and the use of high-capacity neutron absorbing racks would be considered.

17.2.1.8.2 Estimated Time of Readiness for Practical Design. Design and construction capabilities are available for water-cooled basin storage of spent fuel at reactor sites, at fuel reprocessing sites, or at separate locations. The estimated time required to build, license, and begin operating a storage facility is 6 to 8 years.

17.2.1.8.3 Major Development. Development work that would enhance the existing technology of water basin storage (as well as other storage concepts), though not required for design, include:

- ° Development of improved methods to detect and isolate failed fuel.
- ° Development of improved instrumentation to determine fissile content of fuels.
- ° Development of improved methods to predict stability of spent fuel during transport and storage.

IN THE
UNITED STATES COURT OF APPEALS
FOR THE SECOND CIRCUIT

NATURAL RESOURCES DEFENSE COUNCIL, INC.,)

Petitioner,)

v.)

UNITED STATES NUCLEAR REGULATORY
COMMISSION and UNITED STATES OF
AMERICA,)

Respondents,)

POWER AUTHORITY OF THE STATE OF NEW
YORK, et al., AMERICAN ELECTRIC
POWER COMPANY, et al., BOSTON EDISON
COMPANY, et al., PENNSYLVANIA POWER
& LIGHT COMPANY,)

Intervenors.)

No. 77-4157

CERTIFICATE OF SERVICE

I hereby certify that true copies of the JOINT APPENDIX
in the above-entitled action were mailed this 27th day of
January, 1978, by first class mail from Palo Alto, California,
to the following:

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January 27, 1978

Mr. Daniel A. Fusaro, Esq.
Clerk
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for the Second Circuit
United States Courthouse
Foley Square
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Re: Natural Resources Defense Council v.
Nuclear Regulatory Commission, No. 77-4157

Dear Mr. Fusaro:

Enclosed for filing please find ten (10) copies of
the JOINT APPENDIX in the above-entitled action.

Thank you for your assistance in this matter.

Sincerely yours,

Helene Linker
Helene Linker

HL:gg
Enclosures
cc: All counsel of record

